JAWS S3 98 Conference

Las Vegas, NV

15-18 June 98

Volume 3

Jaws S3 98 Conference

AQ# U99-02-0191

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DoD Directive 5230.24, "Distribution Statements on Technical Documents," 18 Mar 87, contains seven distribution statements, as described briefly above. Technical Documents must be assigned distribution statements.

Tom Minnich
per phone call with J. Camp 10/22/98
Authorized Signature/Date

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Telephone Number

JAWS S3 98 Conference Volume 3
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Wednesday, 17 June 1998

Thursday 18, June 1998

Meeting Technology Needs of the Warfighter...Y2K and Beyond

Trent Thomas
Quantum Research

QUANTUM RESEARCH INTERNATIONAL

Bitter Medicine--

- Willy and Ray

QUANTUM RESEARCH INTERNATIONAL

Agenda

- Introduction
- The Environment
- Conflict
- The Threat
- Technology
- View from the Trenches
- Conclusion

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THE ENVIRONMENT

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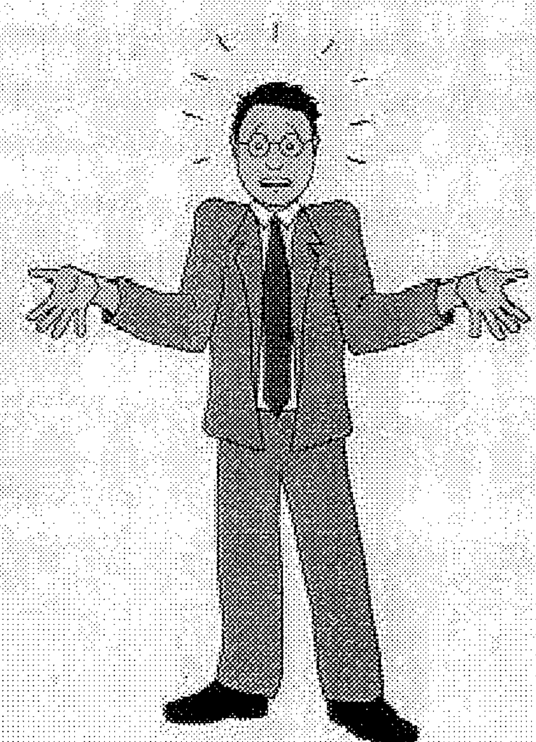
2010 or 1986?

The way we were…

- Me
- My son
- Juanita's Kid



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CONFLICT

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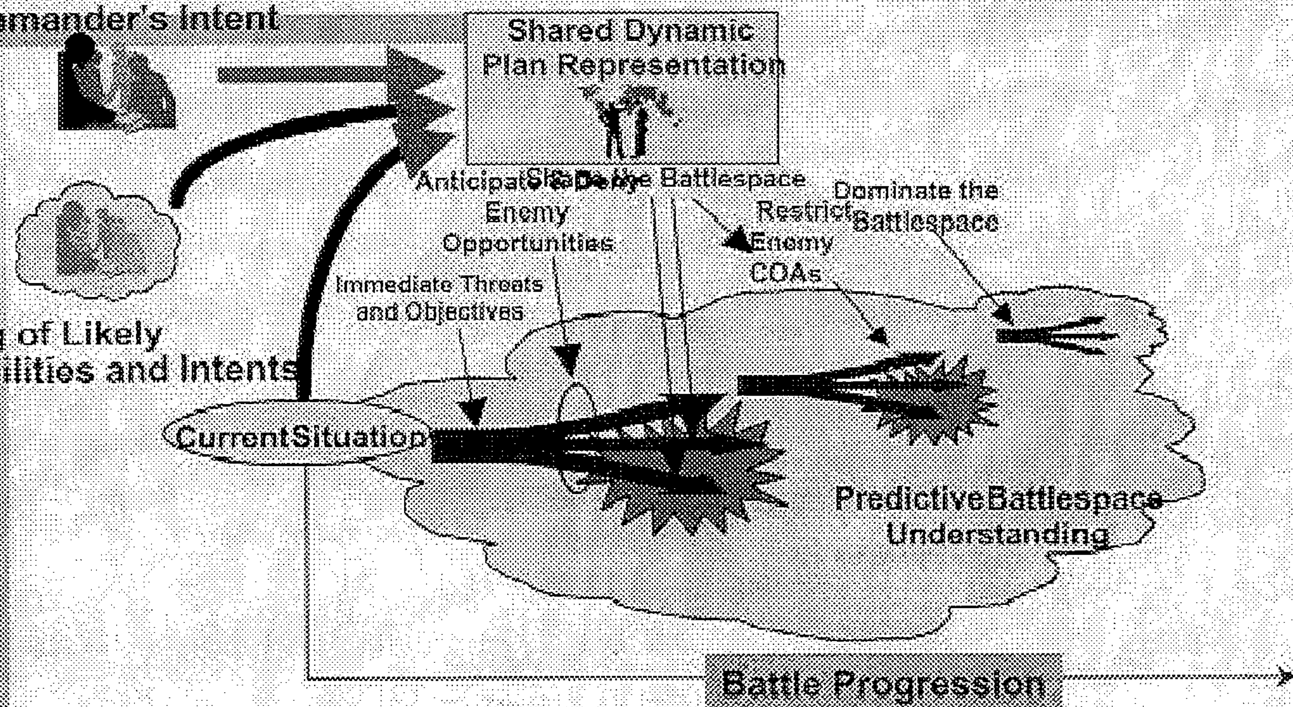
Time—A Dimension that Must be Mastered!



- Predict and Preempt
- Integrate the Force
- Execute Time-Critical Missions

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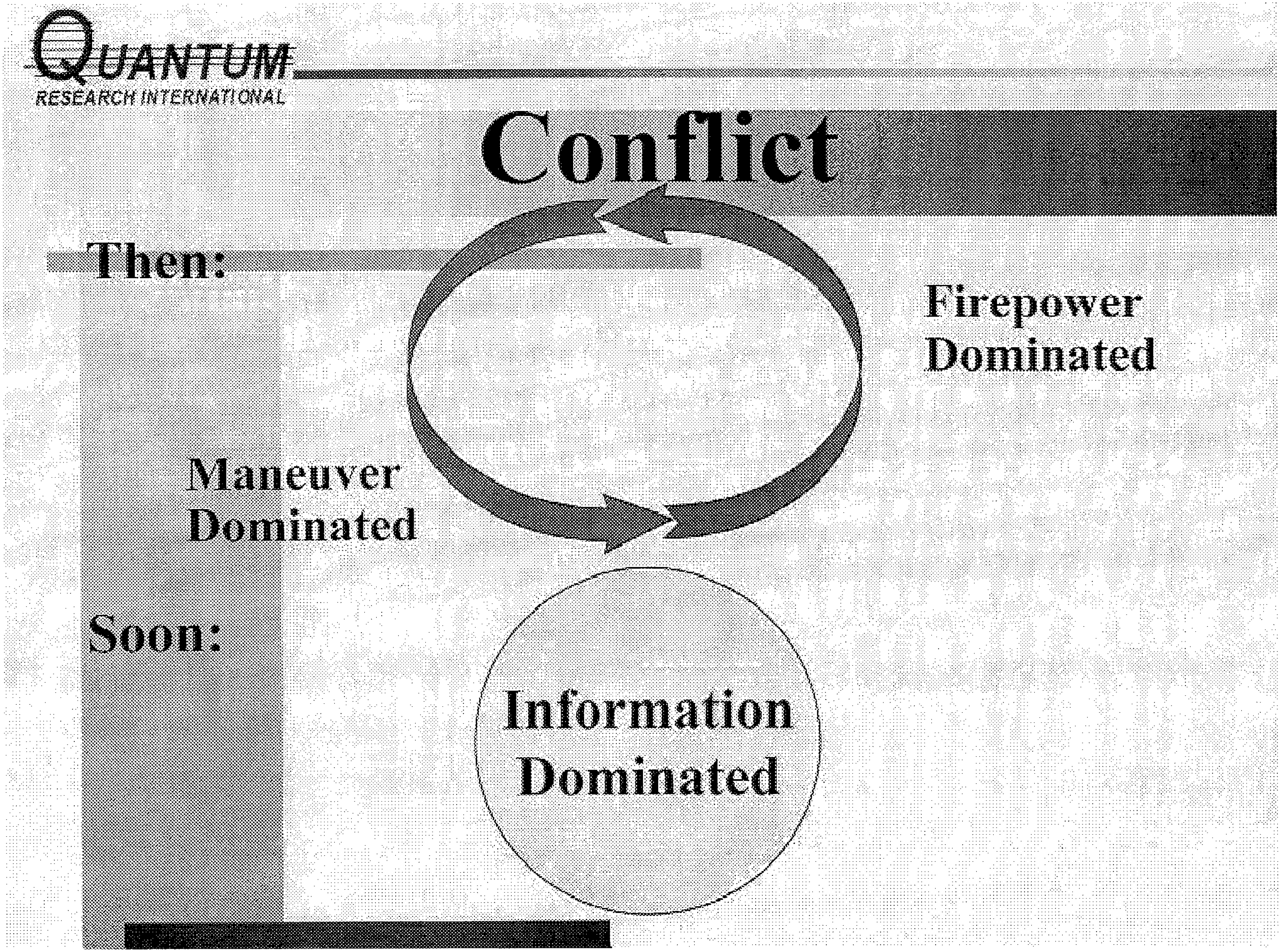
The Expanded Battlespace

Beyond Traditional Physical Dimensions of Width, Depth, and Height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Conflict
Then:
Firepower Dominated
Maneuver Dominated
Soon:
Information Dominated

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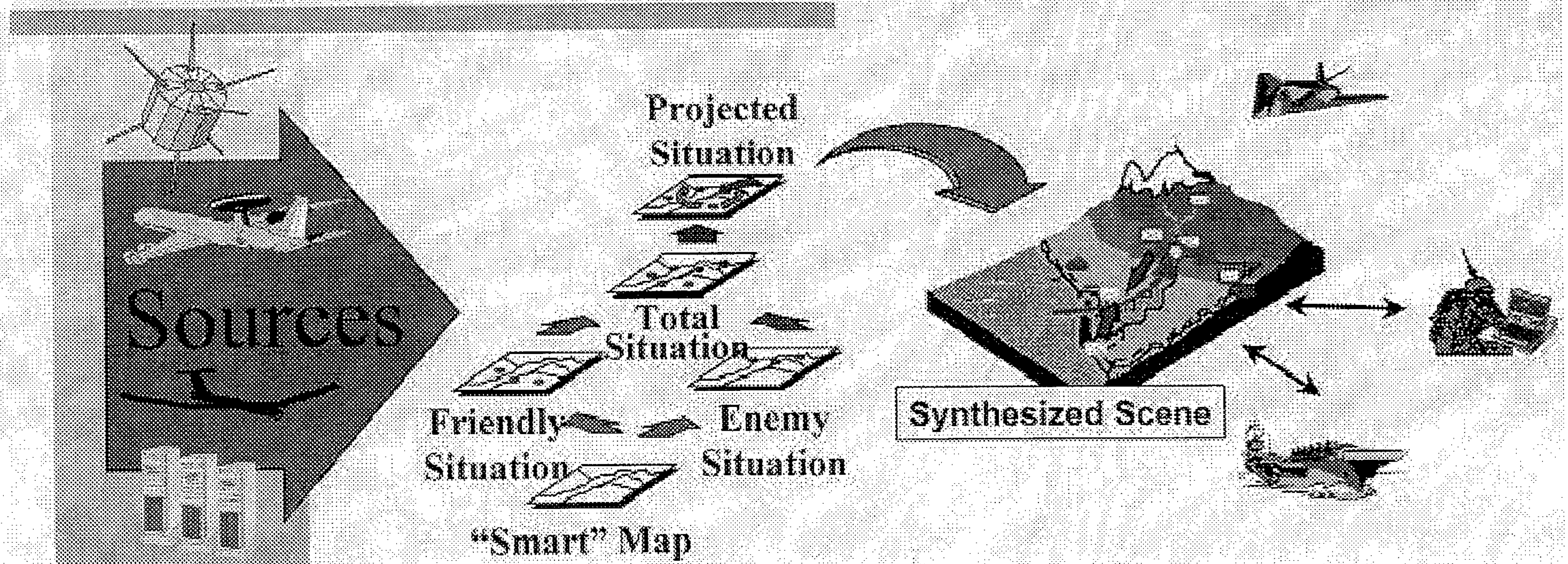
Information-For Informed Decisions



- Consistent Battlespace Understanding
- Precision Information Direction

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THE THREAT

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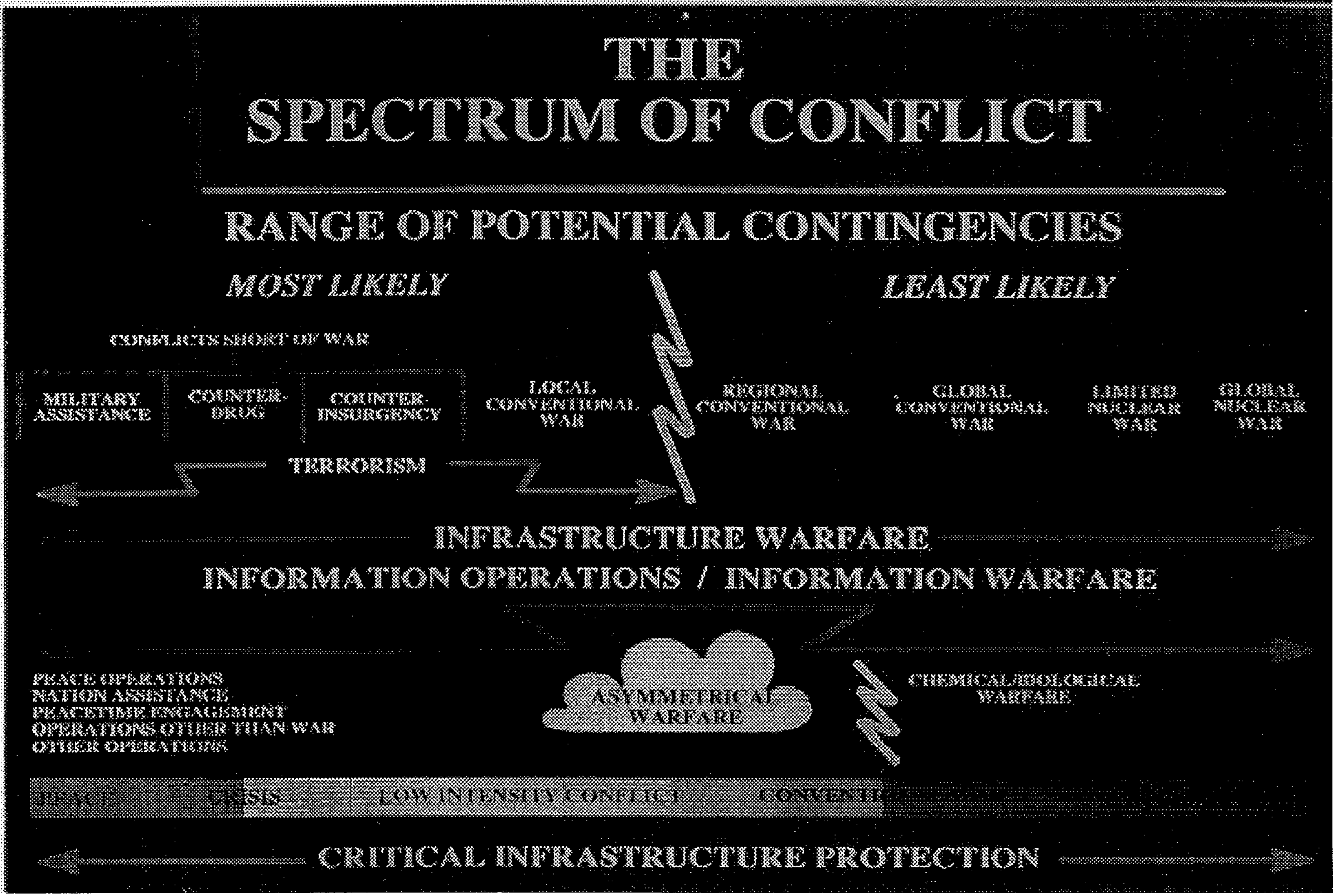

Big Wars/Medium Wars/Small Wars/Non-Wars

- National Military Strategy
  - -Two, nearly simultaneous conflicts
- National Military Reality
  - -Somalia
  - -Rwanda
  - -Haiti
  - -Bosnia

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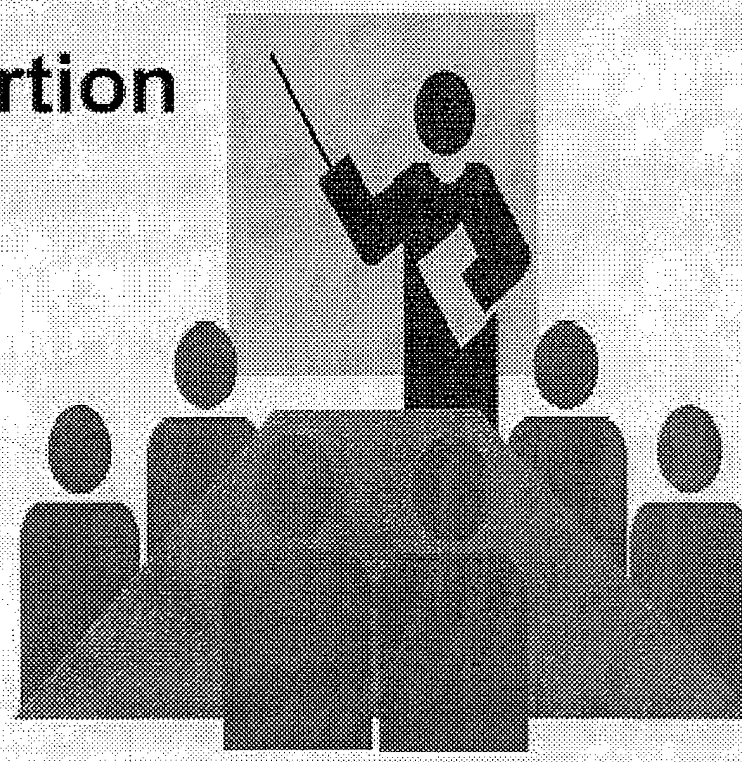
Plan for the Future

- Joint Vision 2010

  -Information Dominance

  -Technology Insertion



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Force XXI

Begun in 1992, Force XXI is the comprehensive and ongoing modernization process to take the Army to year 2010. The process consists of an interactive and linked series of evaluations, exercises and experiments influencing critical decisions about the Army's future organization, equipment, training and doctrine.

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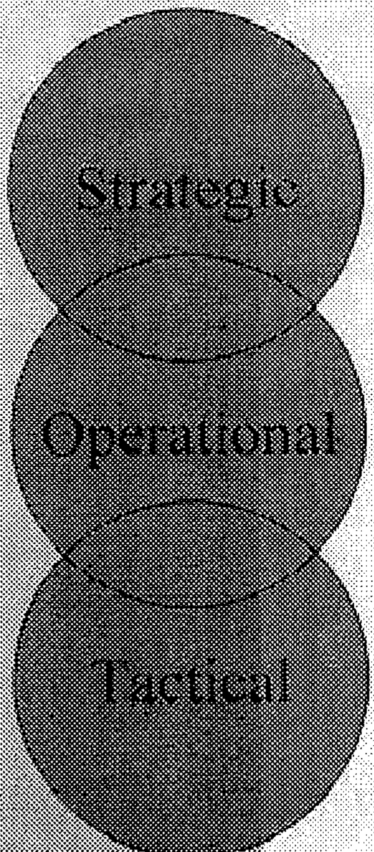
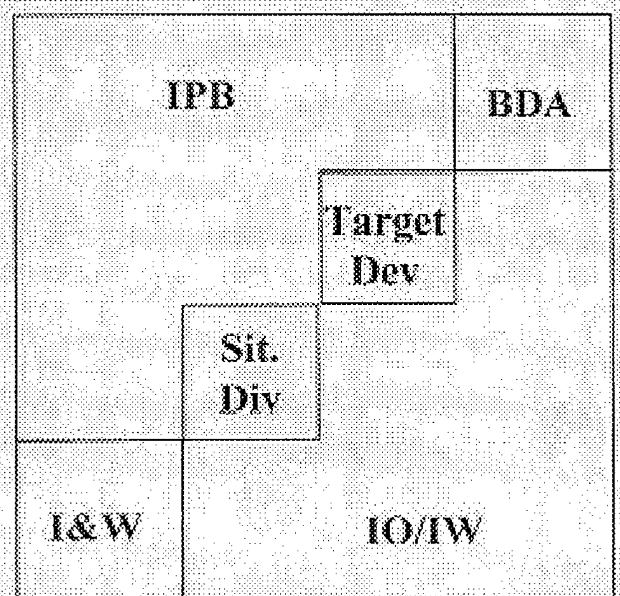
INTELLIGENCE--The Process





Intentions
Capabilities
Organizations/
Nodes
Equipment
Signatures

MTI	CM/CB Radar	SIGINT/MASINT	IMINT/HUMINT
Movers	Shooters	Emitters	Sitters

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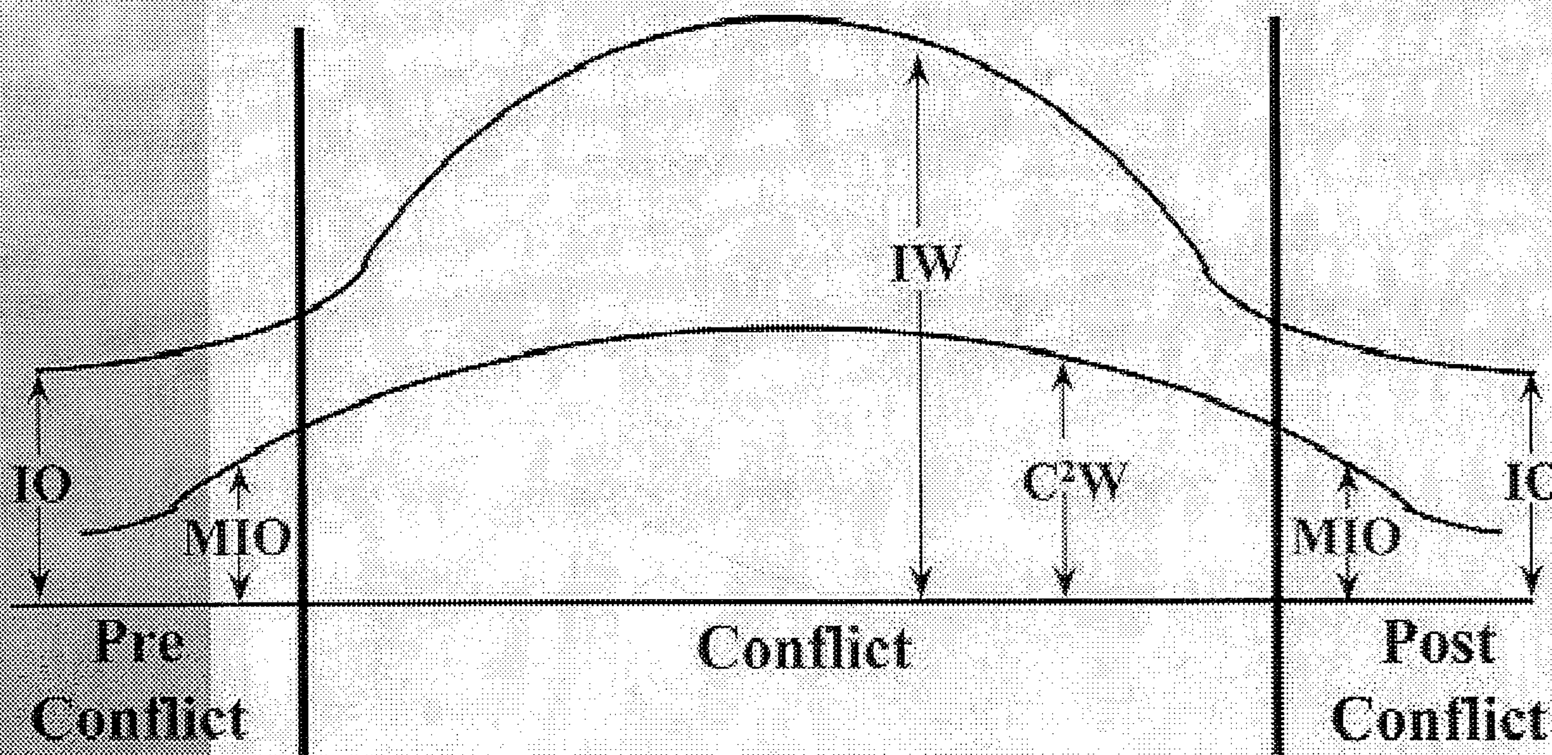
Information Warfare/Operations



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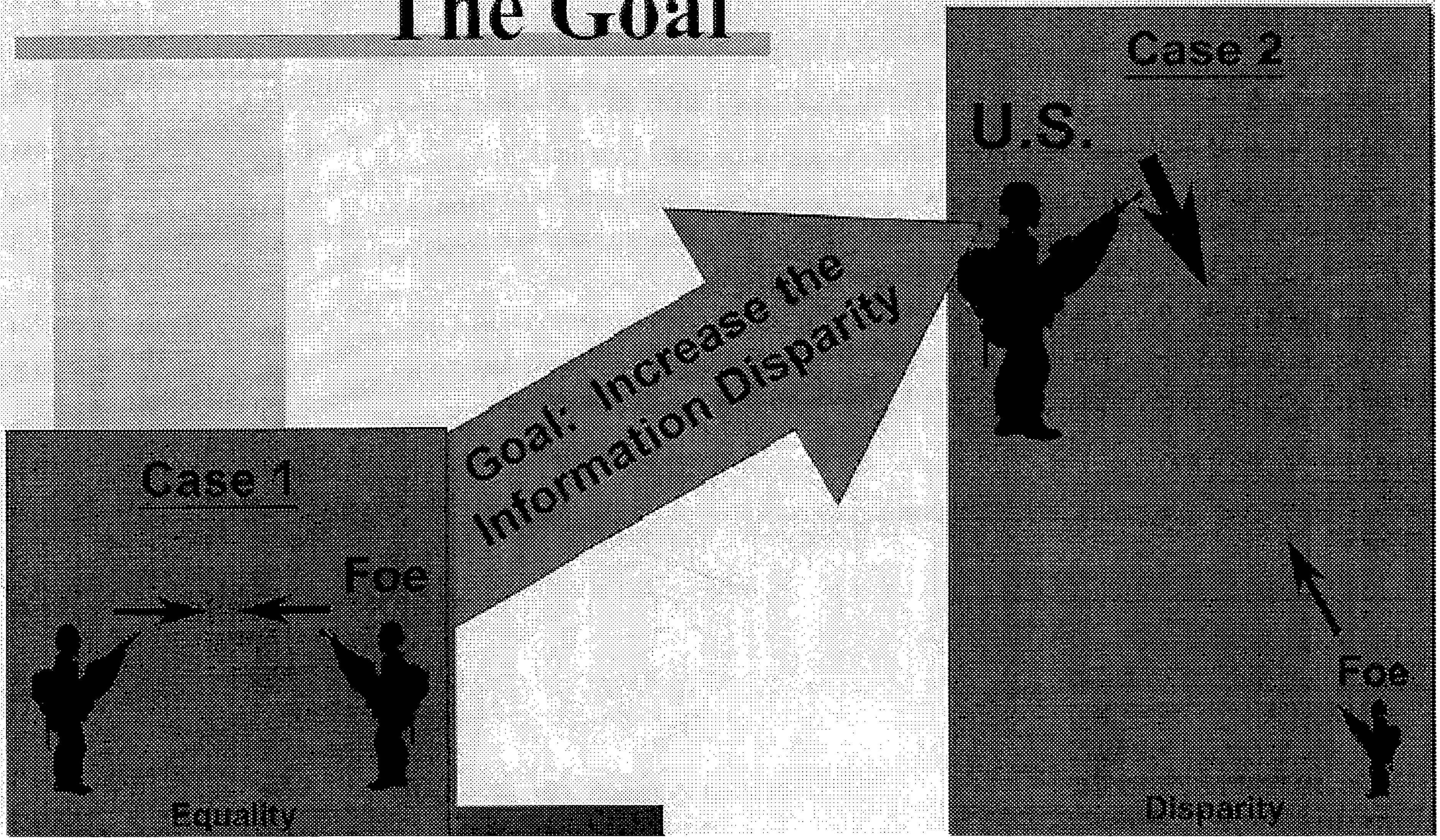
Information Warfare-- The Goal



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TECHNOLOGY

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Technology --Key Question--

What would you do, though now impossible, if possible, that would make warfighting easier?

- See through buildings
- Shoot around corners
- Jump two stories

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What We Need--Information Ops

- Improved Blue Force Location Updates
- Rapid Movement of Tailored Information
- Seamless Communication Across All Systems
- Dynamic Network Management
- Red Force Situation—Fidelity; Distribution; Intent; Potential
- Asset Availability: Where; How Much; When Available

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The "Big Eight" Technology Areas

- Universal Transaction Services
- Assurance of Service
- Distributed Environment
- Understanding the Battlespace
- Direct the Information
- Predict and Preempt
- Force Integration
- Execution of Time-Critical Missions

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Universal Transaction Services—Needed Technologies

- Self-Adapting Tactical, Mobile Networking
- High-Rate, Asymmetric, Tactical, Mobile Communications
- Broadcast with Filtering
- Universal Information Transaction Mechanisms
- Automated Protocol Language, Syntax, Translation
- Condition Information by Compression, Coding, Abstracting
- Location-Independent Addressing; Connectivity on Demand

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Assurance of Service—Needed Technologies

- Information Warfare Surveillance and Defense Tools
- Tools for Projecting and Visualizing "Grid" in Operational Terms
- Low-Cost Appendages and Shells for Commercial Systems
- Anticipatory Services and Management Tools
- Multilevel, Adaptive Information Security

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Distributed Environment—Needed Technologies

- Intelligent Agents
- Massive Data Storage and Management
- Geolocation Support
- Heterogeneous Multimedia Conferencing
- Automated Mediators and Database Management Tools
- Automated Language and Syntax Translation

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Understanding the Battlespace—Needed Technologies

- Automatic Target Recognition and Battle Damage Assessment
- Multisensor Information Fusion and Sensor Cross Cueing
- Image Understanding and Pattern Recognition
- Recognition, Routing, and Analysis of Data
- Intelligent Agents—Retrieve, Filter, Deconflict
- Agents for Intelligent Inferences
- Real-Time Distributed Object Management
- Uncertainty Management and Visualization

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Information Direction—Needed Technologies

- Automatic Target Recognition
- Multisensor Fusion and Cross Cueing
- Automated Battle Damage Assessment
- Intelligent Agents for C4ISR Tasking
- Improved Data and Uncertainty Visualization
- Rapid Modeling and Simulation (M&S) for Sensor Coverage
- M&S for Spectrum Dominance and Information Warfare

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Predict and Preempt—Needed Technologies

- Rapid Modeling and Simulation (M&S) with C3I for Situational Assessment COA
- M&S for Mission Preview, Rehearsal, an Training
- M&S for Spectrum Dominance and IW Effectiveness
- Distributed, Collaborative, Continuous Dynamic Planning
- Information Fusion
- Automated Nodal Analyses
- A[redacted]apon Pairing and Updates

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Force Integration—Needed Technologies

- Distributed, Collaborative, Dynamic Planning/Scheduling
- Distributed, Collaborative, Virtual Workspaces
- Rapid M&S Including C3I
- Automated Target and Infrastructure ID; Behavior and Change Detection; and Battle Damage Assessment
- Multi-Sensor and Information Fusion
- Search and Text Understanding

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Execution of Time-Critical Missions—Needed Technologies

- Multi-Sensor Fusion
- Automatic Target and Infrastructure Recognition
- Automated Intelligence Preparation of the Battlespace (IPB)
- Distributed, Collaborative, Workspace for Intelligence, Surveillance, and Reconnaissance ISR
- Cognitive Displays with Real-Time Presentations
- Decision Support Tools and Automated Planning

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VIEW FROM THE TRENCHES

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View from the Trenches

Marines

--Switches and dials

--On/Off Switch

--Always On

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View (continued)

Army

- Maintenance

--One of kind

--Mixed fleet

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View (continued)

•Technology

--Henry Ford, “Just because you can do something, don’t mean you ought to do it.”

--‘Cost’ Counts in a dollar driven world.

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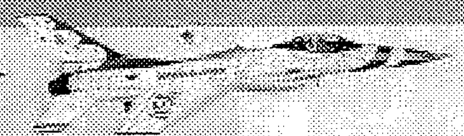
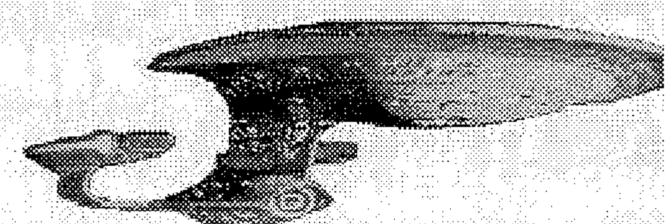
Time Shear



Mach



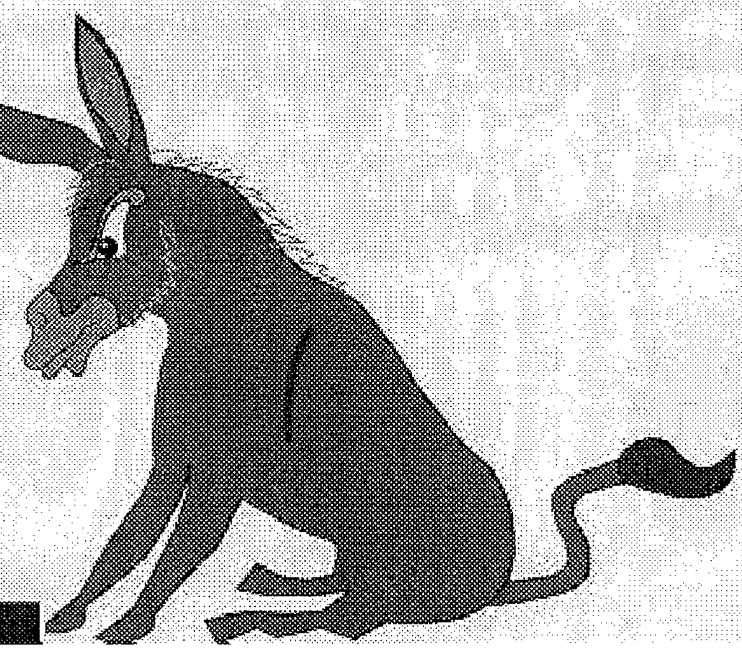
Warp

QUANTUM RESEARCH INTERNATIONAL

Bitter Medicine--

- Willy and Ray

...but it might be good for you



E S I P

MISSION CRITICAL SOFTWARE

Embedded Computer Resources (ECR) Support Improvement Program

Providing Performance-Based Support

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ESIP Director
OO-ALC/TI-3
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Email: jarzombj@software.hill.af.mil
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Overview

Relevance to the Software Industry

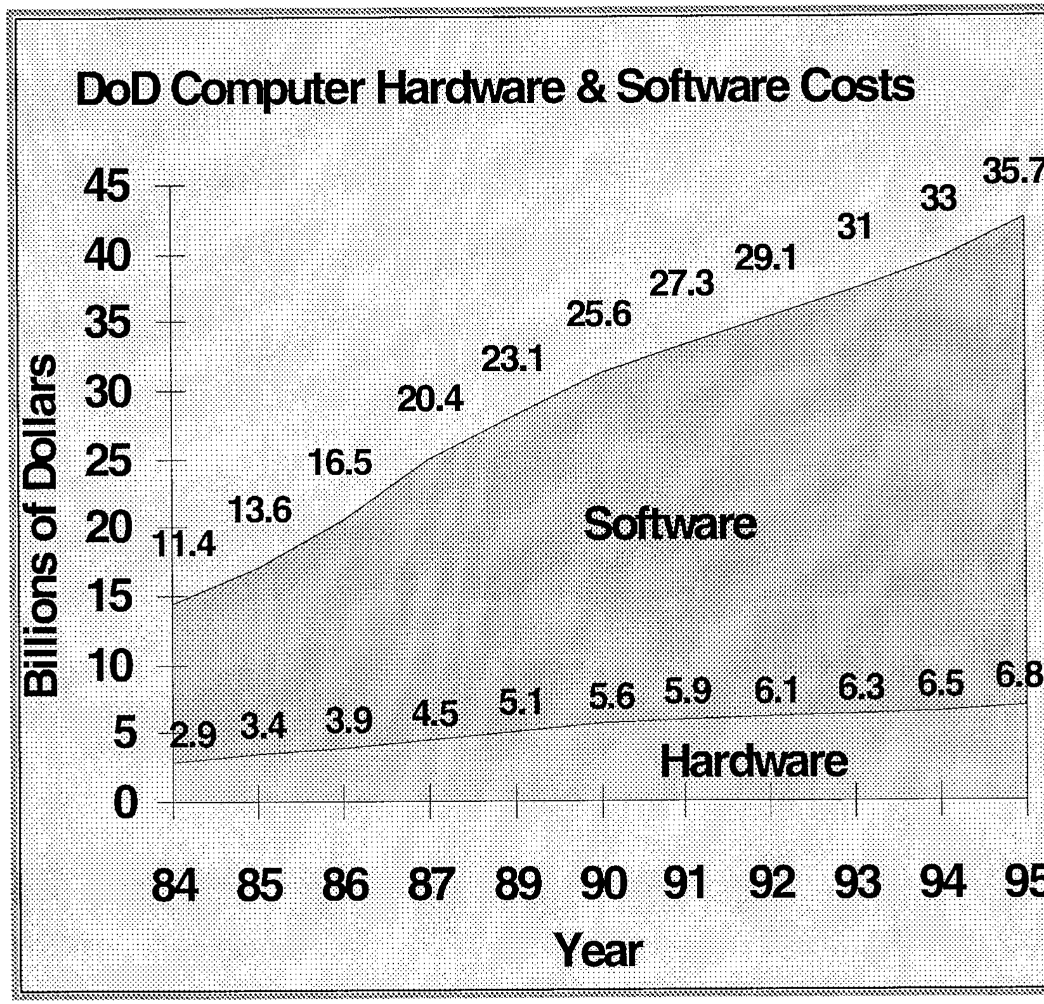
- Mission & Business Challenges associated with Software
- ESIP Focus & Support Processes
- Lessons Learned & Opportunities with ESIP Projects
  - AF R&D in conjunction with Commercial Independent R&D
  - Software Technology Support
    - Technology Information Services
    - Technology Evaluation & Adoption Services
  - Software Readiness
    - Dissemination of Software Best Practices
    - Software Process Improvement Efforts
    - Integration of Measurement Efforts
- Summary

The Software Challenge

- By 2002, DoD will spend more than $20B on s/w
- Poor Success Rate for Software-Intensive Projects
  - ⇒ 1% of projects are on-time, on-budget & meet expectations
  - ⇒ 33% software-intensive projects never finish
- Unacceptable Schedule Variance
  - ⇒ Average is 1 Year Behind Schedule
  - ⇒ Average Schedule Missed by 50%
- 75% are “Operational Failures”

National Security Systems Challenges

- The quantity of software in weapon systems is increasing dramatically
- Software provides increased system capability & flexibility
- Increases in program schedules & cost (both in acquisition & sustainment) prompt need for software solutions in Information Technology (IT) in National Security Systems (NSS = MCCR)



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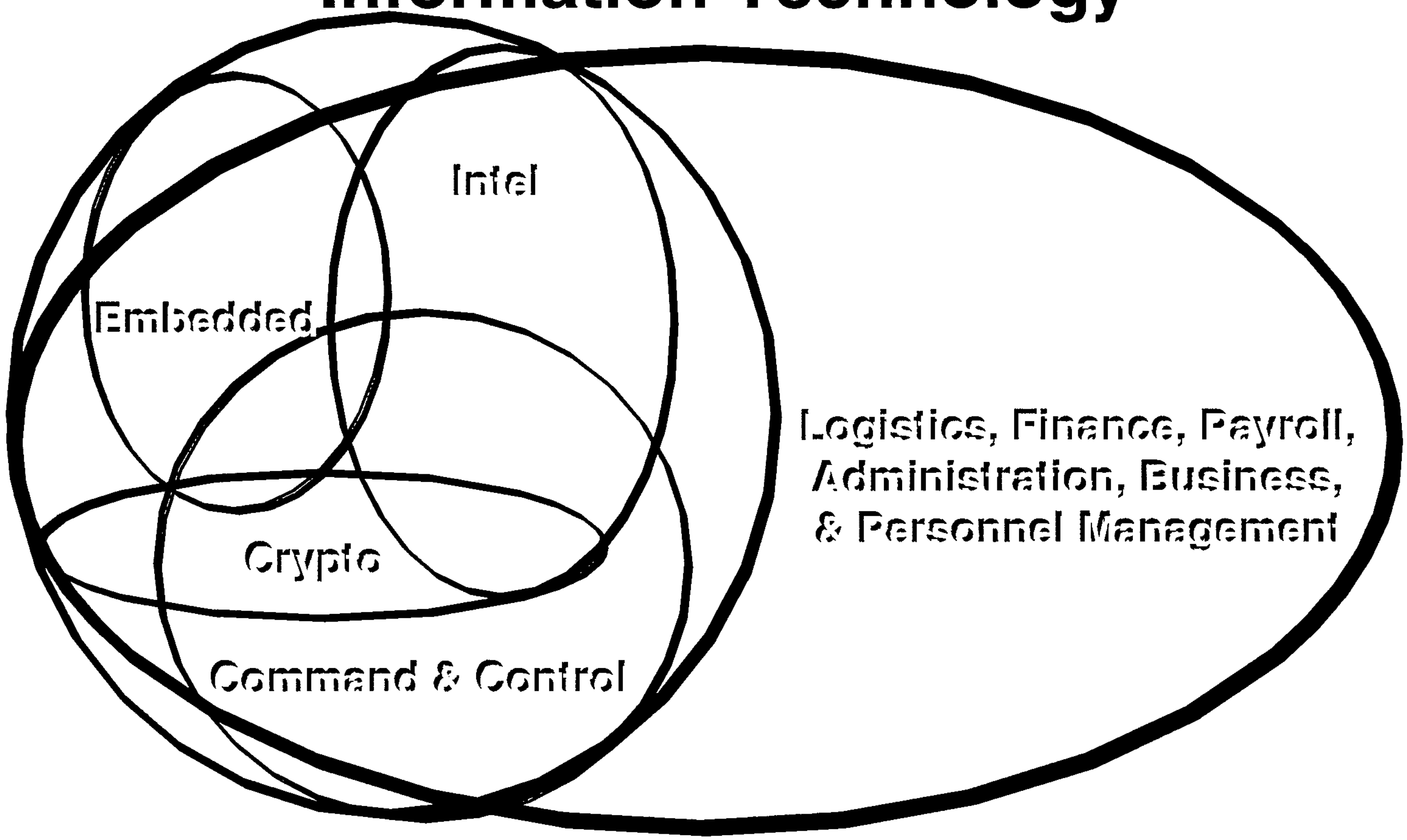
ESIP Focus - Mission Critical Software for IT

Information Technology



ITMRA & DoD Directive 8000.1 define IT National Security Systems (NSS = MCCR)
Mission Critical Computer Resources = C2, Crypto, Intel & Embedded Systems

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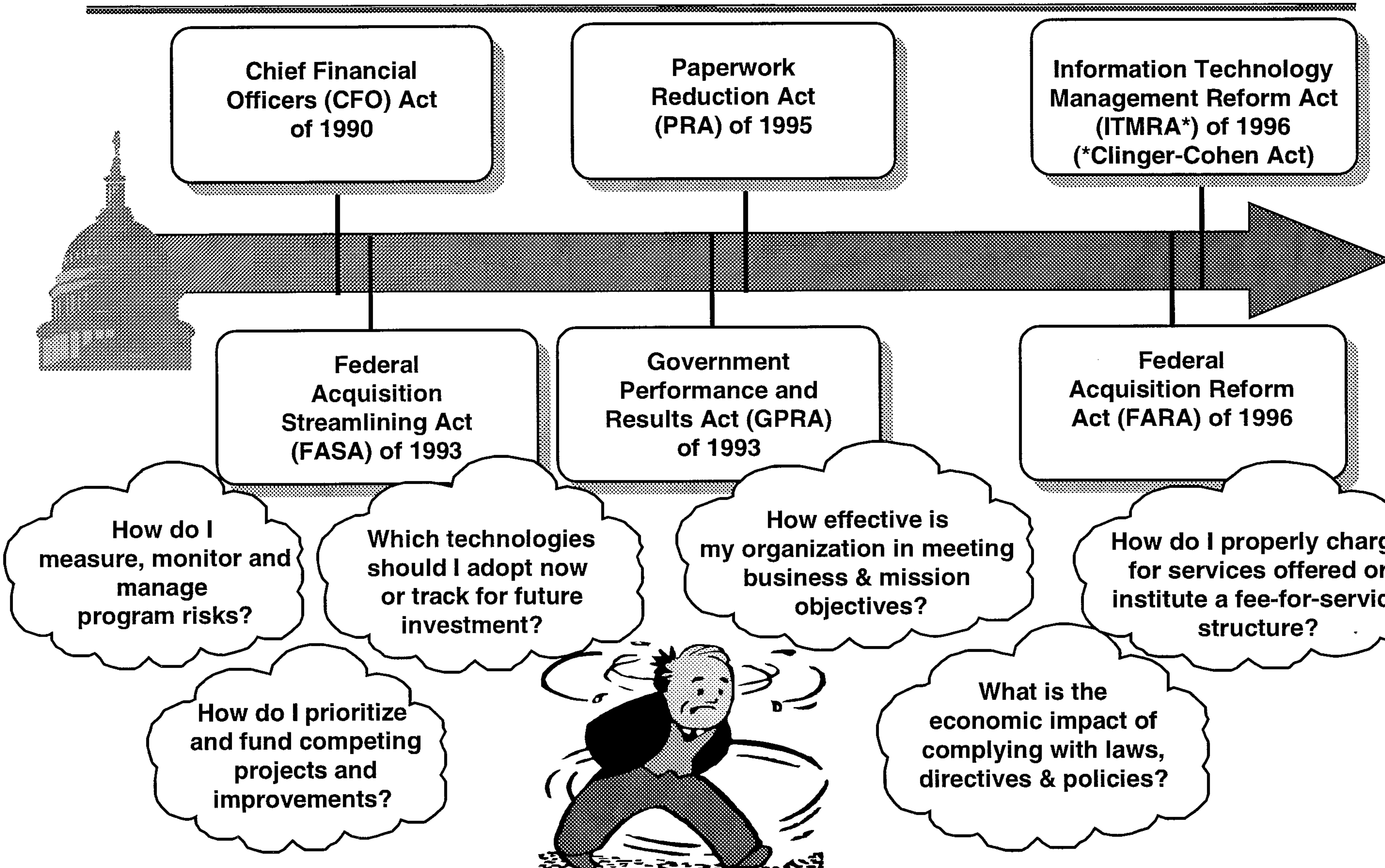
Coping with Business Challenges & Need for Performance Improvement



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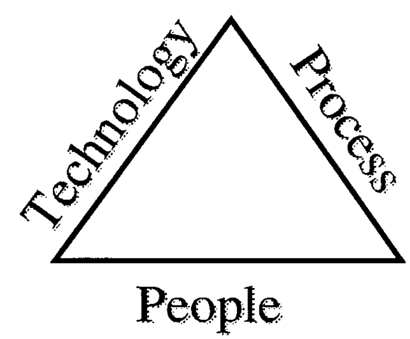
Coping with DoD Business Challenges

- OMB guidance and DoD Directive 8000.1
  - ⇒ place more demands for performance-based & results-based management processes and tools
  - ⇒ guide Information Technology (IT) program expenditures to ensure they provide measurable improvements to mission performance
- Acquisition workforce downsizing & demand for outsourcing
  - ⇒ causes shortage of critical technical expertise in program office staffs
  - ⇒ creates need for more acquisition expertise in non-acquisition staffs
- Audit agencies scrutinize program offices' capability maturity
  - ⇒ GAO recognizes software's growing importance/prevalence
  - ⇒ Program offices' software acquisition processes reviewed in audits

ESIP Support Role in Managing Software-Intensive Systems

- **PM focus for development, acquisition & sustainment**
  - ⇒ More complex responsibilities associated with risk management
    - Outsourcing reduces direct control; retains execution responsibilities
    - Reliance on COTS capabilities increases risks with program insight
  - ⇒ More demand & need to use program measurements
  - ⇒ More need for enterprise-wide process improvement
  - ⇒ More direct user influence on resource allocation
- **Need for strategic alliances to match needs of various programs with appropriate providers**



ESIP Support Role

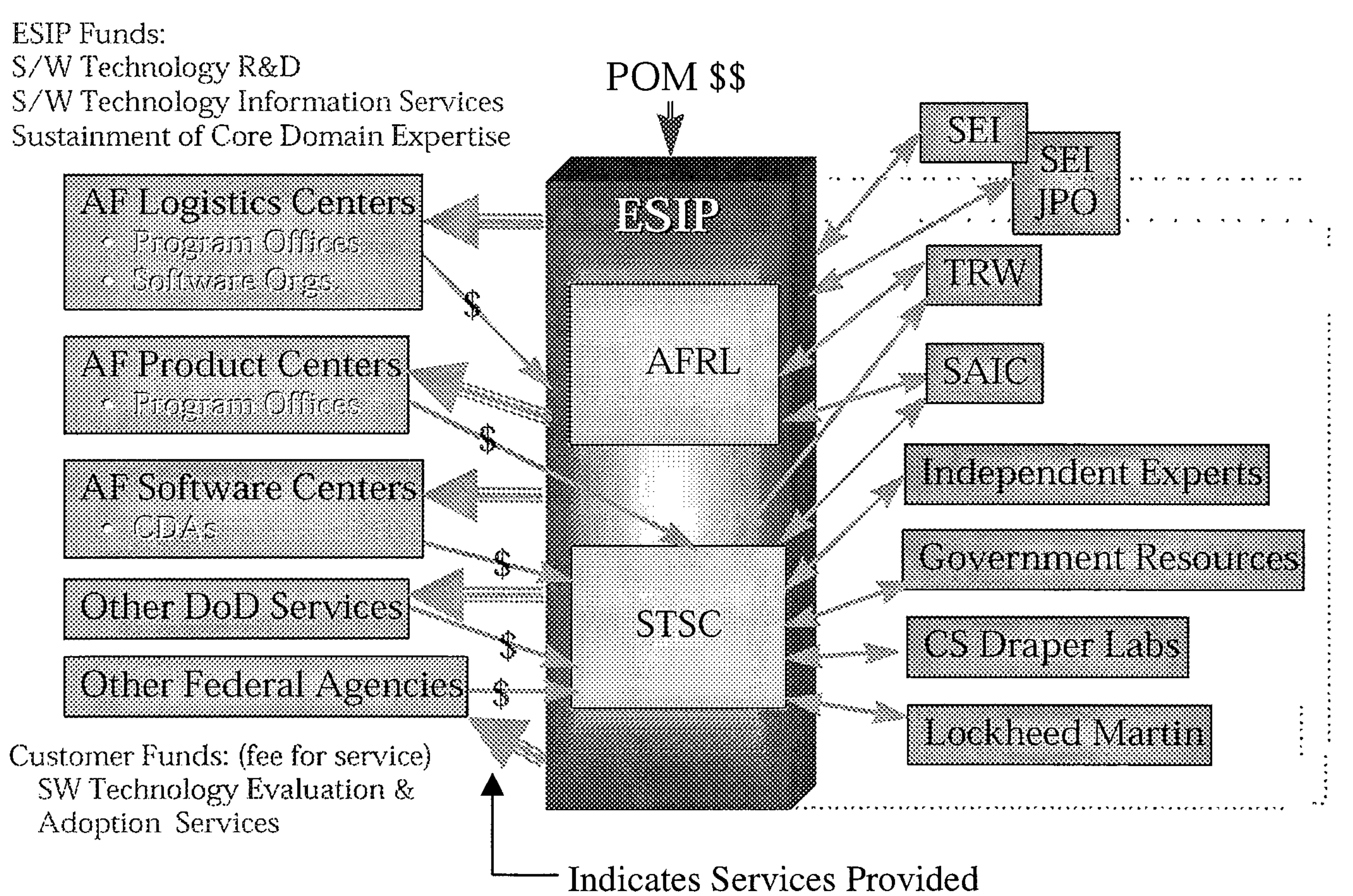
ESIP PMD 3118 / PE 78611

Mission

- Provide an infrastructure to **identify, develop, and transition effective technologies** to software organizations to enhance their ability to develop, acquire, manage, test, and support mission critical software in National Security Systems.
- **Facilitate the fielding of affordable, reliable, sustainable, technologically superior weapon and support systems** through the efficient use of limited resources.
- For the **adoption of effective technologies**, ESIP provides:
  - Information & engineering services
  - Hardware & software procurement
  - Research & development services

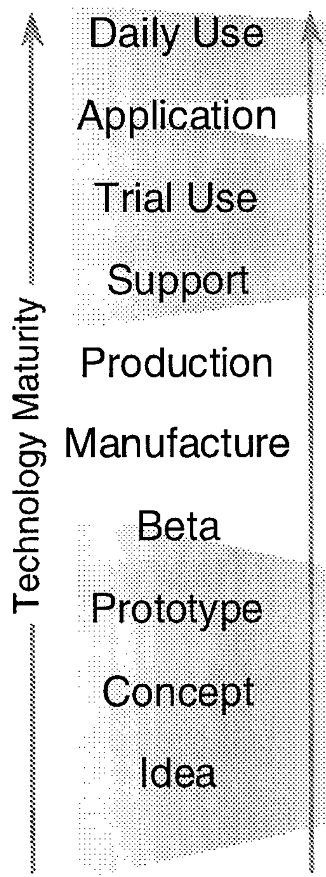
ESIP Support Role

ESIP Virtual Program Office Support to Customers



ESIP Support Role

ESIP Role in the Technology Maturization Process



- **Software Readiness** (AFMC ALCs)
  - ESMP Software Process Improvement (SPI -SEPGs)
  - SPI Support Functions & Best Practices (thru STSC)
  - Integration of Measurement Efforts (thru STSC)
  - Software Stock, Store & Issue (SCC ACPINS)
- **Software Technology Support** (STSC Ogden ALC)
  - Technology Information Services
  - Technology Evaluation Services
  - Technology Adoption Services & Support Processes
- **Research & Development** (AFRL, WPAFB)
  - Requirements Formulation
  - Tool Prototype Development & Evaluation
  - Technology Concept Development & Evaluation
- **Needs Analysis** (ESIP Office with STSC & AFRL)

ESIP PMD Task #2
Research & Development

- **Develop/demonstrate support concepts & systems**
  - ⇒ Environment for real-time testing & support
  - ⇒ Integrated performance monitoring & control systems
  - ⇒ Test/Data reduction methodologies & tools
  - ⇒ Fault tolerant systems & complex systems diagnostics
  - ⇒ Software instrumentation
  - ⇒ Legacy System Migration
  - ⇒ Readiness/rapid reprogramming methodologies
- **Transition successful prototypes for application by AF mission-critical software support organizations**
  - ⇒ Focus on common, multi-user software problems
  - ⇒ Apply technology across platforms and organizations
  - ⇒ Team with industry to build and evolve best technologies

ESIP R&D Value/ROI

E S I P

ESIP-SPONSORED PROJECTS PRODUCE HALF OF AF RESEARCH LAB AVIONICS SUCCESS STORIES

- 3 to 1 — Customer Funding to ESIP Funding
- 10 to 1 — Cost Avoidance to ESIP Funding
- 100 to 1 — Cost Avoidance to ESIP Funding for fully commercialized technology

- Software enhancements/fixes operational more rapidly
- Dramatic increases in software mission effectiveness
- Increased capability to meet evolving mission critical software demands
- Companies have collaborative opportunities for IR&D

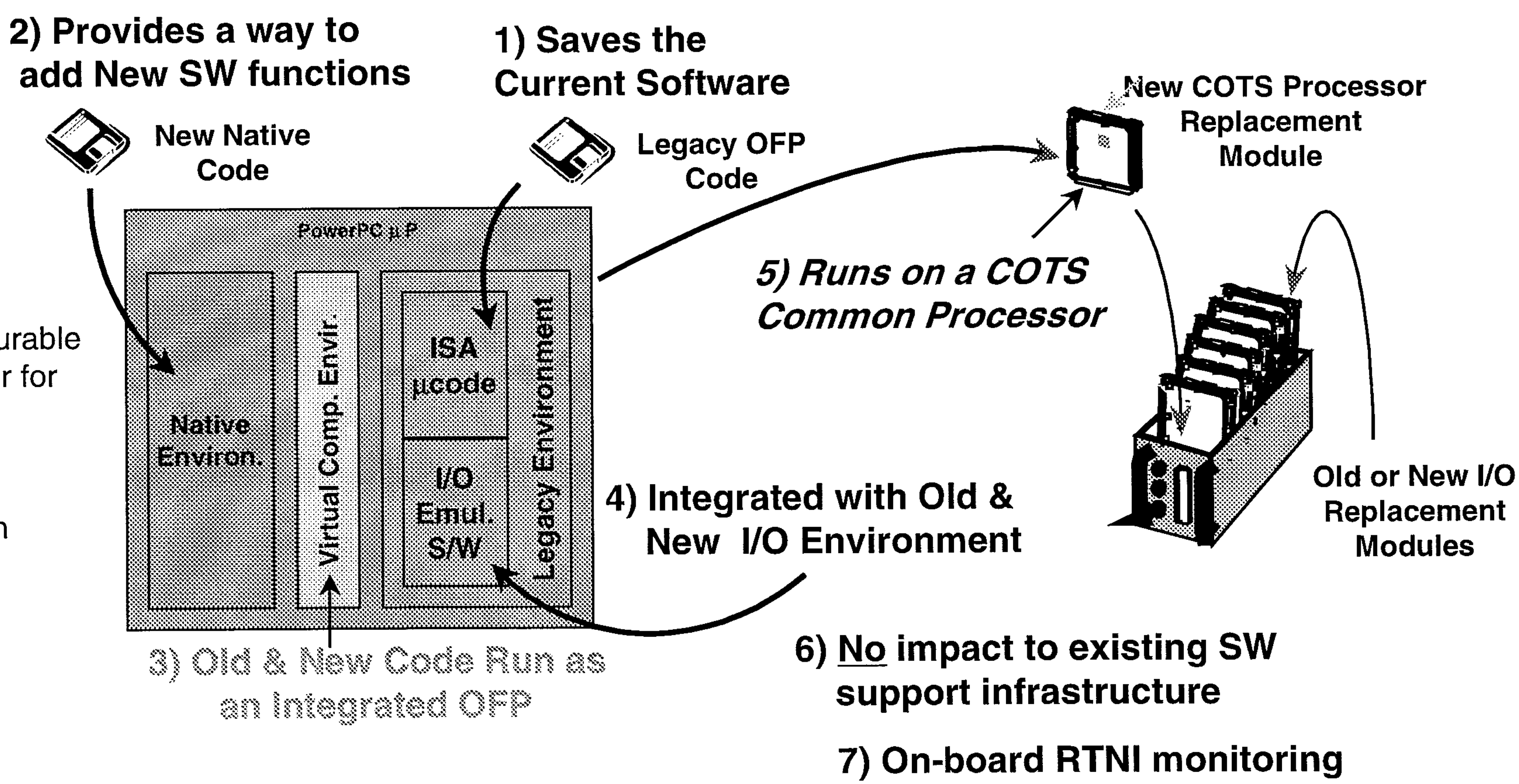
Example R&D Project Meeting a Need

E S I P

- Need: Force structure is budget driven; reliant on legacy systems
  - ⇒ New procurements reduced;
  - ⇒ Most 2010 systems in inventory today; older systems to pick up the slack
- Existing software-intensive systems need improvements to:
  - ⇒ Solve parts obsolescence problems
  - ⇒ Meet new/changing mission requirements
  - ⇒ Keep mission capabilities operating longer at reduced cost
- What can be done?
  - ⇒ Change hardware (capitalize on technology advances; replace obsolete embedded computers)
  - ⇒ But save the legacy software (preserve original investment; establish known, good starting point)
  - ⇒ And incrementally add capability (rapid deployment, managed change; use modern object-based software architectures)

Reconfigurable Processor for Legacy Avionics Code Execution (RePLACE)tm done with TRW IR&D

- *Situation Case :* Service life extension of DOD software-intensive systems
- *Case Impact:* Aging systems - parts obsolescence & performance limitations
- *R&D Objective:* A cost effective, lower risk approach to system upgrades
- *R&D Focus:* Develop a software based technology that:



Reconfigurable Processor for Legacy Avionics Code Execution

Reasons for Considering RePLACE™

- Lowers NRE for legacy processor upgrades
  - ⇒ Reuse of existing software (preserve original investment)
  - ⇒ Establish known good starting point for managed software upgrades
  - ⇒ Reduces need for much regression testing
- Lowers Sustainment Cost
  - ⇒ Takes advantage of COTS-based, open systems hardware
  - ⇒ Modern software development environment
  - ⇒ Better software/system diagnostics through real-time, non-intrusive monitoring (dramatically enhances testability/supportability of the hardware and embedded software)
  - ⇒ Enables affordable approach to performance enhancements
- Licensed tool available; easily used by organizations

See RePLACE presentation in JAWS Software & Information (SI) Technology Focus Group on Thursday, 18 June at 1300 hrs

ESIP PMD Task #3
Software Technology Support (STS)

Provide Software Technology Support Center (STSC) to perform:

- Technology Information Services
- Technology Evaluation Services
- Technology Adoption Services & Support Processes

Software Technology Support Approach

Define Framework	Assess Capability	Develop Technology	Deliver Service
POLICY	MODELS	TOOLS	CONSULTING & SUPPORT
ITMRA **GRPA** **FASA** **FARA** **US12207** **DoDD 8000.1**	**CMMs** **SDCE** **SCE** **PSM** **PMBOK**	**COCOMO** **ISWAP** **AFAM** **VTS** **Control Panel** **INSIGHT**	**Adoption** **Evaluation** **Information** **Process Improvement**
Congress OSD Service HQs Material Cmds	**STSC** SEI SPMN ASC/EN PSM	**AFRL** SPMN PSM ASC/EN Industry	**STSC** **SEPGs** SPMN SEI Commercial

*** ESIP-Sponsored Activities: AFRL - STSC - SEPGs**

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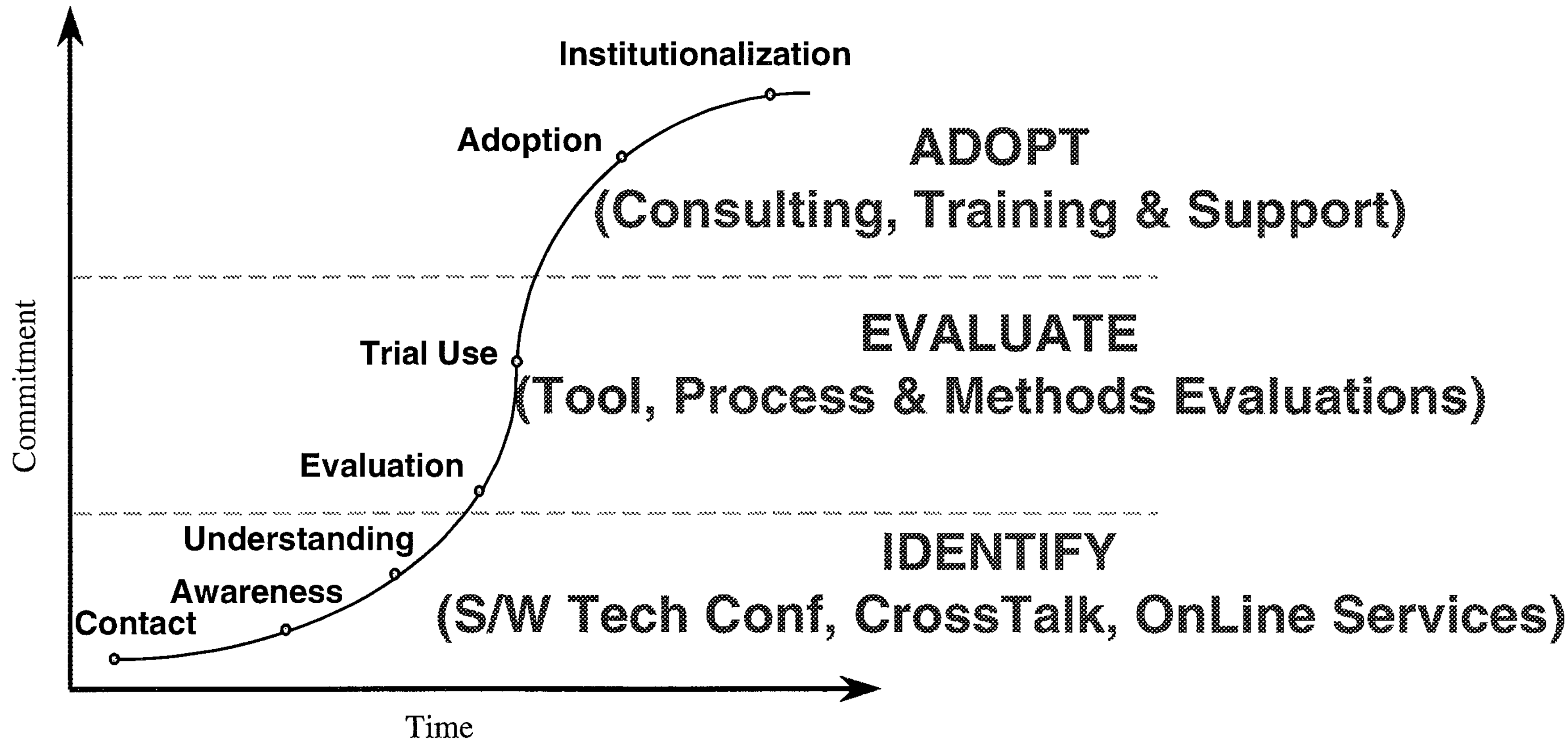
ESIP PMD Task 3:
Software Technology Support (STS)

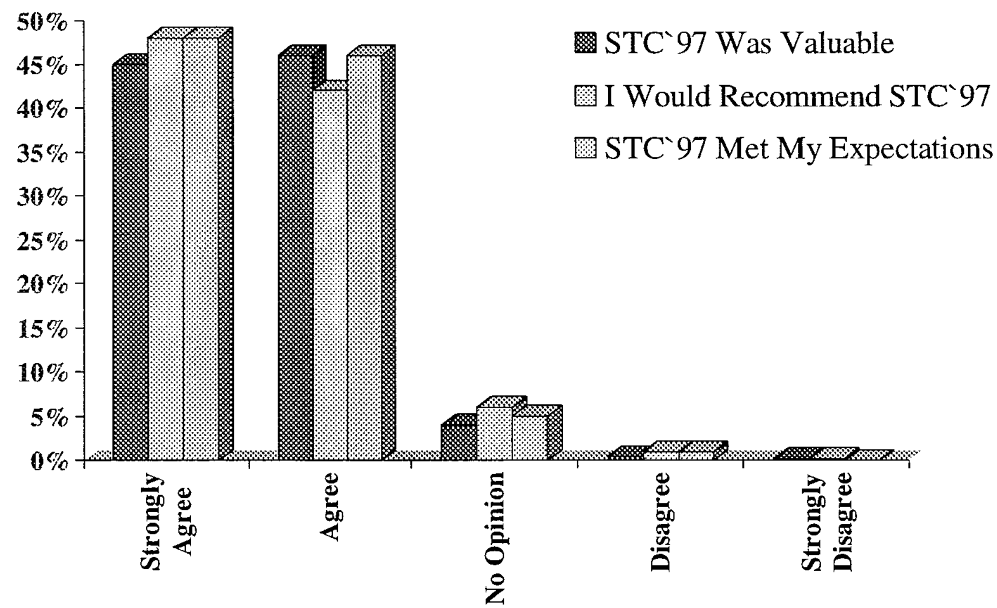
STS Center (STSC) helps organizations improve their software development, acquisition & sustainment efforts.



Technology Information Services

Software Technology Conference (STC)

- Responsive to DoD Software Community:
  - ⇒ Focused on Practical Solutions and Geared to Government Needs
  - ⇒ Co-sponsored by All Military Services & DISA
  - ⇒ STC '97 & STC '98 had a 92% Approval Rating
  - ⇒ Over 3300 participants for last two



- STC '98:
  - ⇒ Theme: Knowledge Sharing-- Global Information Networks
  - ⇒ 20-23 Apr 98 in SLC, UT
  - ⇒ http://www.stc98.org
  - ⇒ 10 tracks & 3 exhibitor tracks, including a JAWS S3 Track

Technology Information Services

E S I P

CrossTalk
The Journal of Defense Software Engineering

- Inform & Educate the Defense Software Community
  - ⇒ DoD Software Policy
  - ⇒ Software Engineering Technology
  - ⇒ Field Experience and Lessons Learned
- Increase Awareness of Successful Technologies
- Readers report gaining applied ideas
  - ⇒ 54% report gaining 2-3 good ideas applied to their projects
  - ⇒ 38% report 4 -10 good ideas applied to their projects
- 19,000 Hard-Copy Subscribers
- Average of 12,000 Hits On-Line per Month

Technology Information Services

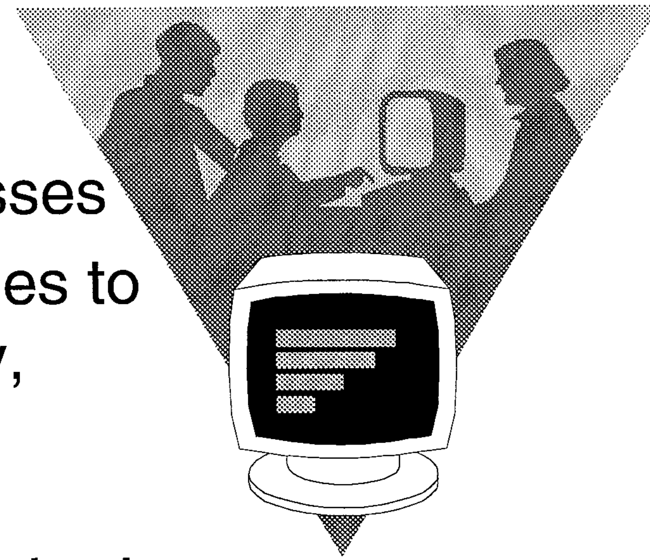
Software Technology Reports

- Tech Reports provided by the STSC:
  - ⇒ vital products of Software Technology Evaluation efforts
  - ⇒ to consistently reflect the "state of practice"
  - ⇒ to reflect changes in Federal, DoD & AF guidance
- Tech Reports cover broad range of s/w technology
  - ⇒ Systems Engineering & Development and CMMI
  - ⇒ Program Management & Software Acquisition
  - ⇒ Reengineering and Y2K support
  - ⇒ Metrics & Measurement support
  - ⇒ Client/Server/Process

Technology Evaluation Services

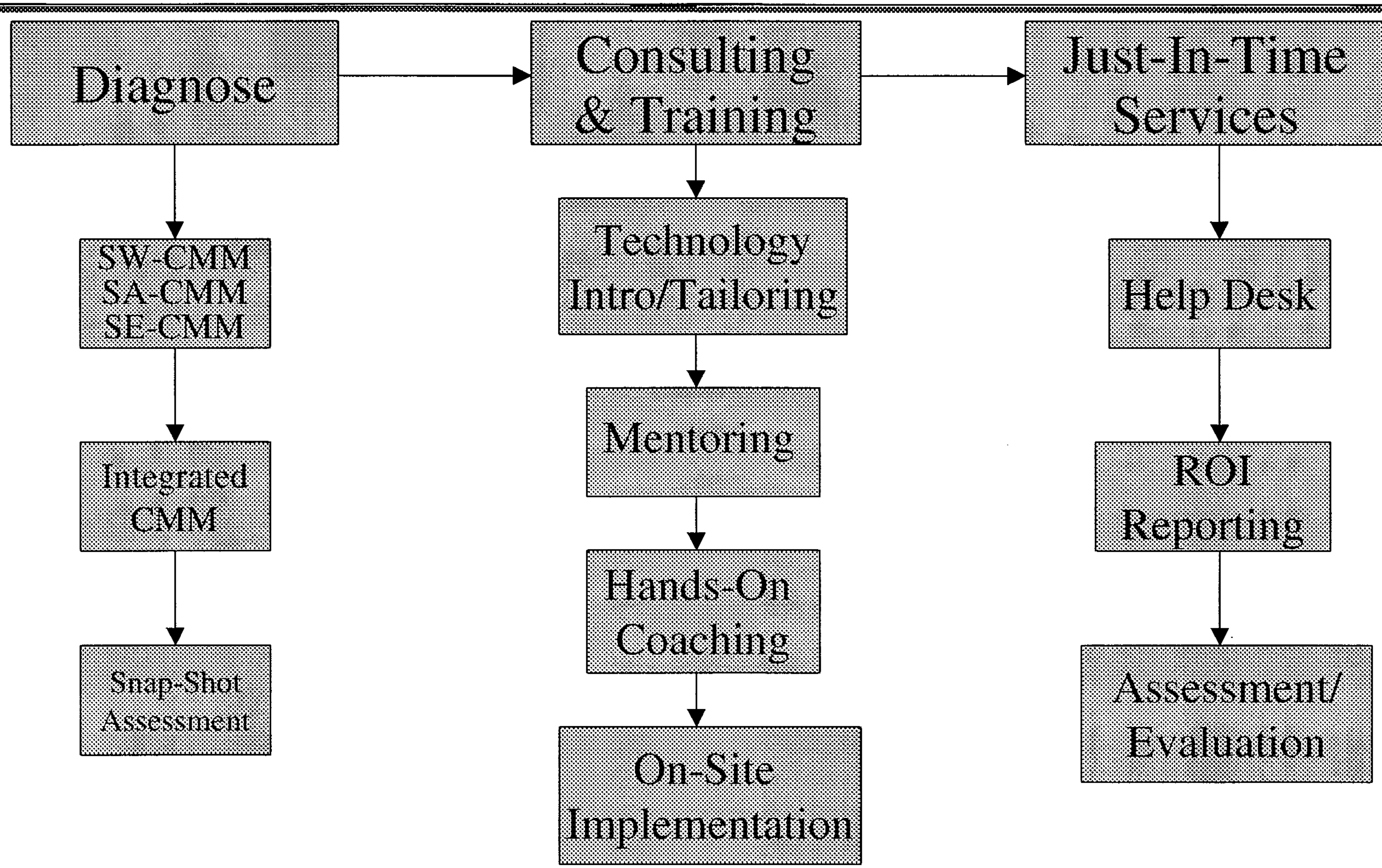
- Help organizations identify, assimilate, pare down, evaluate & select proven technologies
- Research, classify, validate, demonstrate, evaluate, analyze, compare & recommend technologies to improve production quality, efficiency or predictability
- Provide evaluation services and reports for:
  - ⇒ Integrated Environments & Object-Oriented Development
  - ⇒ Reuse, High Order Languages, and Reengineering
  - ⇒ Project Management, Configuration Management, & Documentation
  - ⇒ Process Definition, Requirements Engineering, & Software Design
  - ⇒ Software Measures/Metrics, Quality Engineering & Testing

Technology Evaluation & Adoption Services



- Help software organizations
  - ⇛ exploit resources, measures/processes
  - ⇛ to regularly use effective technologies to improve software production quality, efficiency or predictability
- Provide organizational needs analysis, strategic planning, team development, technical workshops, hands on guidance, and implementation counsel & mentoring

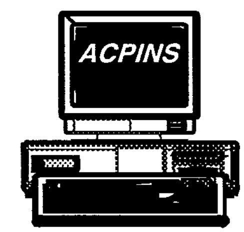
Technology Adoption Services & SPI Support Functions



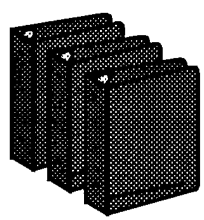
ESIP PMD Task 4: Software Readiness

Software Readiness Tasks

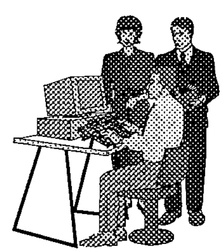
- Upgrade AF software stock, store & issue capabilities
- Disseminate software best practices
  - Provide updates to "Guidelines for Successful Acquisition & Management of Software Intensive Systems"
- Support software process improvement efforts
- Integrate measurement efforts



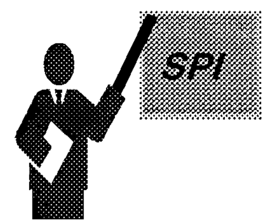
Web-based Enterprise



Technical Guidance



Program Support

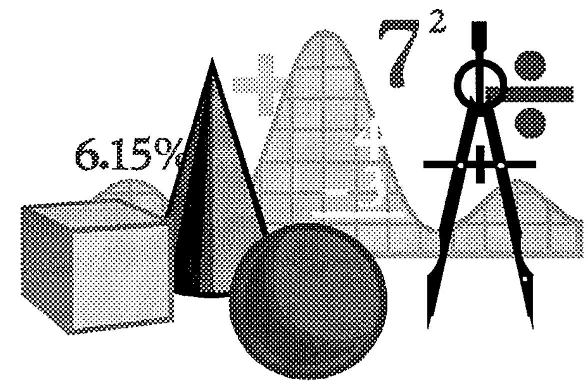


Training Courses

Software Readiness

Support Software Process Improvement (SPI)

- Software Engineering Process Groups at AFMC Centers
- Corporate SPI Support Functions thru STSC
  - ⇒ Corporate SPI Guidance for AFMC SEPGs
  - ⇒ SPI Help Desk
  - ⇒ SPI Return on Investment (ROI) reporting
- Capability Assessments & Evaluations
- SPI Training & Consulting thru STSC
  - ⇒ Practical Software Measurement
  - ⇒ Software Acquisition, Sys Engineering, Project Mgt, & Estimation
  - ⇒ Capability Maturity Models (CMMs -- level 2-5 KPAs)
  - ⇒ Integration of CMM Training (with SEI) & Tailoring for pilot projects



Software Readiness

ESIP

Software Process Improvement (SPI) for Supported Programs

- SPI efforts quantifiably justify funding (based on several projects)
  - ⇒ Demonstrated Return on Investment of 3:1 - 9:1
  - ⇒ Earlier Detection of S/W Defects from 22% - 90%
  - ⇒ Reduction in post-release defects from 39% - 84%
  - ⇒ Reduction in schedule time from 19% - 23%
  - ⇒ Reduction in projected schedule variance down to 2%
  - ⇒ Increased Productivity (less rework) of 35% - 75%
  - ⇒ Reduced Sustainment costs by 30% - 55%
- Several ESMP or STSC-supported programs have improved their capabilities based on the SEI Capability Maturity Models (CMMs); reporting improved customer satisfaction in software support

Process Improvement Business Case

CMM Integration Benefits

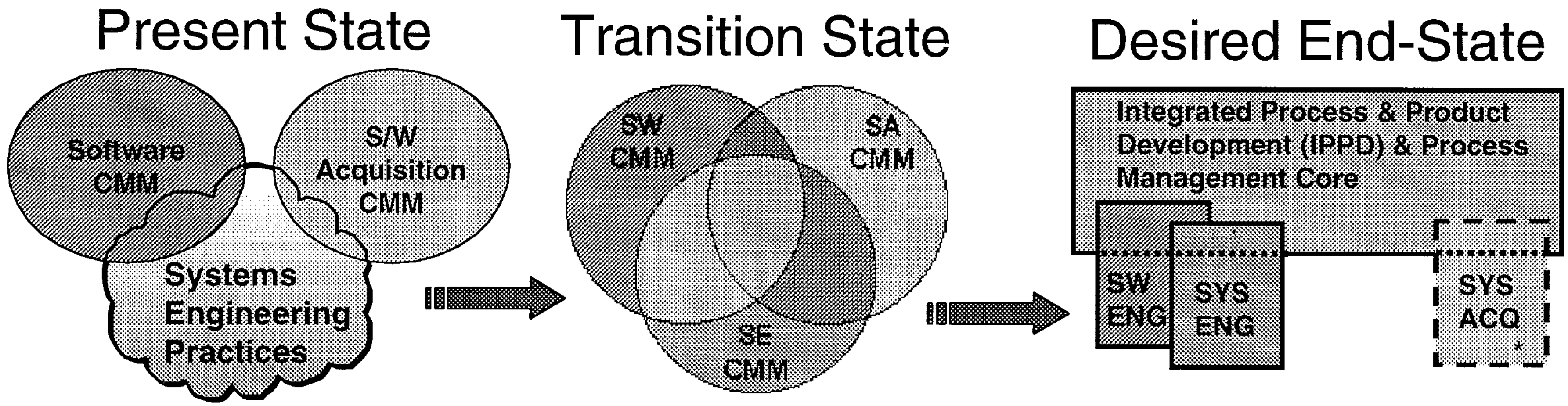
- Integrated CMM leverages experience with individual CMMs
  - ⇒ Use SEI, STSC & AF SEPG infrastructure in transitioning & tailoring
    - More easily obtain improvements in areas addressed in other CMMs
    - Demonstrates how CMMs complement each other
    - More consistent use of CMMs among disciplines
  - ⇒ Integrated CMM-based assessments (gap analysis) provide more complete understanding of enterprise-wide needs
  - ⇒ Supports institutionalization of enterprise-wide process improvement
    - Capability levels provide focus to apply the concept to a single process
    - Maturity levels provide roadmap for sequencing improvement activities
- Gets customers/users involved in process improvement
  - ⇒ Improves service to primary ESIP customers -- Sustainment Practitioners
  - ⇒ Promotes gains in user advocacy for process improvement

Enterprise-wide Process Improvement

ESIP Support Role

- Participation in OSD-sponsored CMM Integration (CMMI) PDT
- Enterprise-wide process improvement for specified programs
  - ⇒ Provide training & tailoring of integrated CMM with support tools
    - Provide training for FAA integrated Capability Maturity Model
    - Provide supplemental training in individual CMM process areas
    - Provide training in use of Aimware tool suite
    - Facilitate loading of tool with models and Center's processes
  - ⇒ Support assessment for gap analysis to determine specific needs
  - ⇒ Provide Train-the-Trainer training in Practical Software Measurement methodology & PSM Insight tool
  - ⇒ Provide follow-on mentoring & hands-on support, as needed
- Support collection of ROI data, lessons-learned and project & enterprise-wide measurements

An Evolutionary Change Approach



Discrete Discipline Models & Practices

FAA Integrated CMM (iCMM)

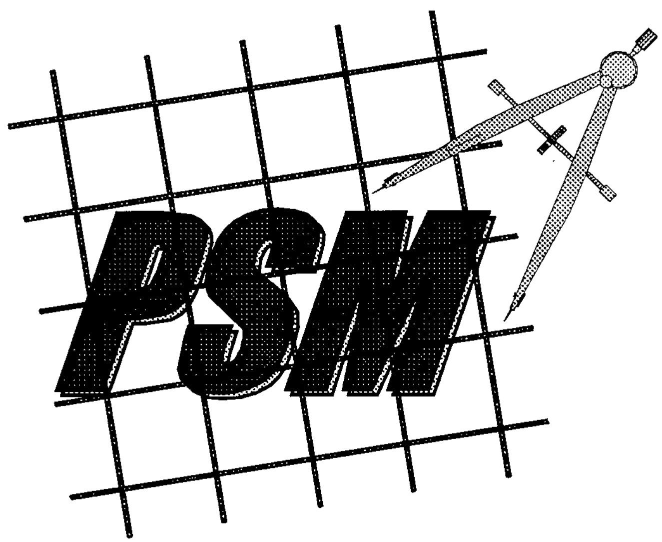
OSD-Sponsored CMM Integration (CMMI)

*Initial release will not include Acquisition model

- Models used to guide enterprise-wide process improvement
  - ⇒ *Several users have requested Acquisition model to be included
  - ⇒ "IPPD is management technique that integrates system acquisition function using inter-disciplinary teams to optimize the process"
- Automated analysis relative to different models to provide gap analysis
  - ⇒ To focus process-specific improvements based on business objectives
  - ⇒ To guide training and resource allocation

Software Readiness

Integrate Measurement Efforts
using
Practical Software Measurement (PSM)
as the foundation for objective project management



Joint Logistics Commanders (JLC)
Joint Group on Systems Engineering (JGSE)

Office of the Under Secretary of Defense Acquisition and Technology -- OUSD (A&T)

ESIP / STSC provide key USAF participation:
- *USAF PSM Development & Transition Partner*
- *AFMC Metrics Working Group Chair*
- *AF Rep on OSD's SEI Software Engineering Measurement & Analysis (SEMA) IPT*

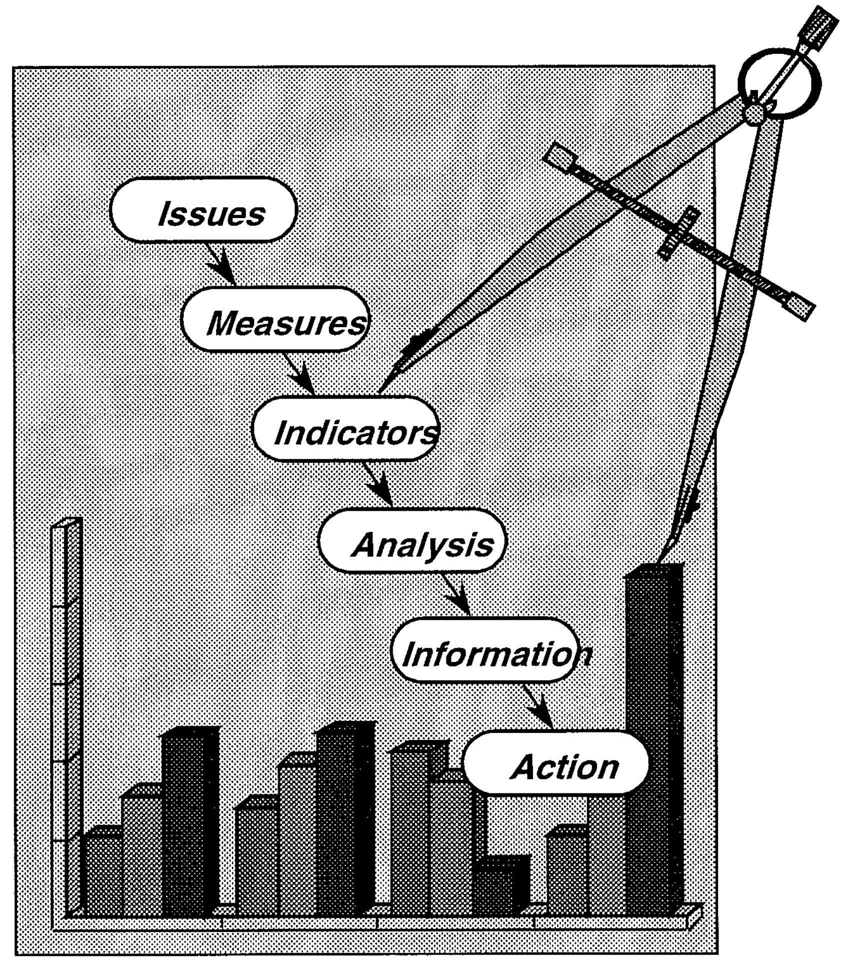
Why Measurement is Important

Today's DoD Project Environment

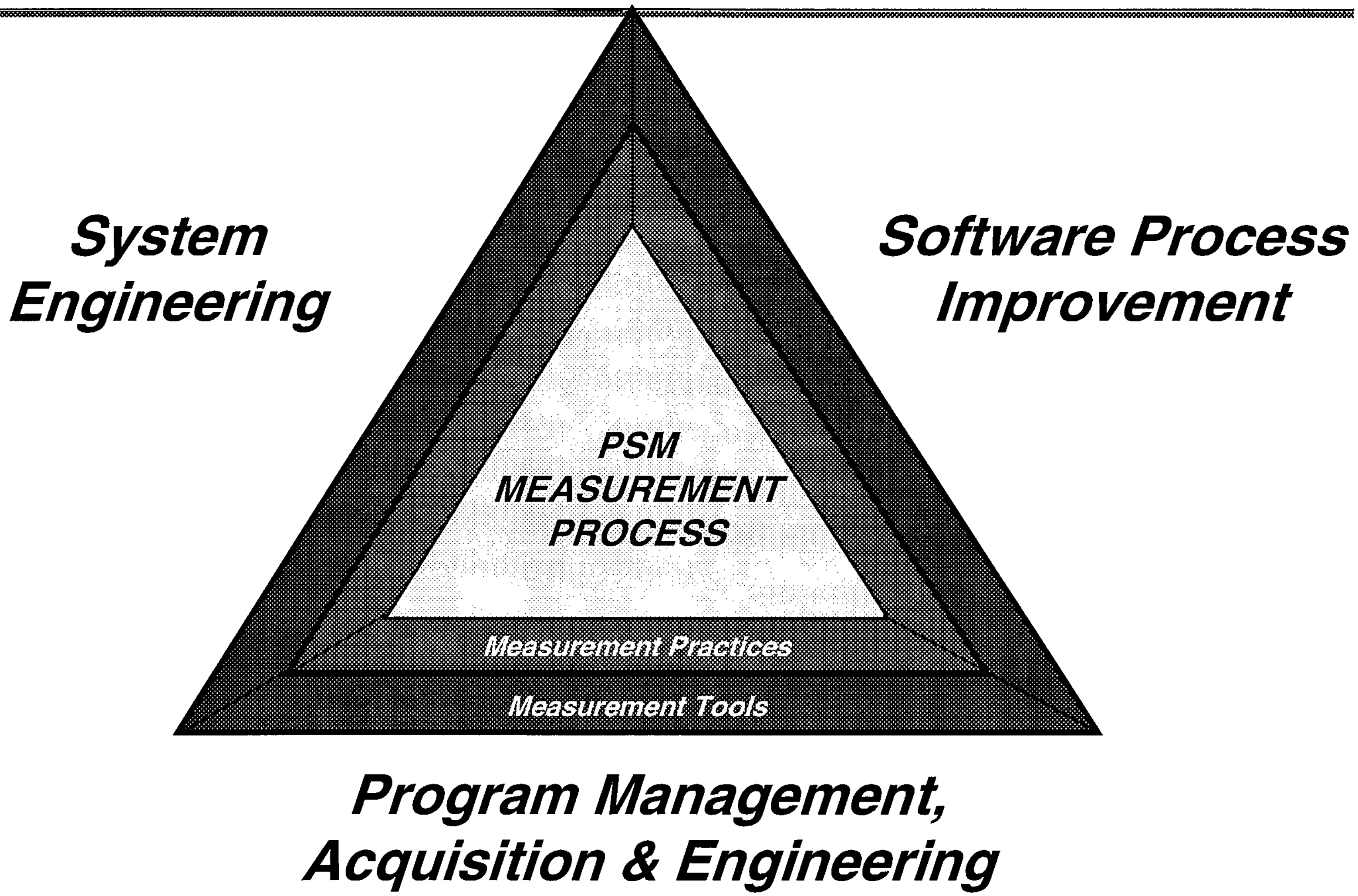
- Acquisition Reform & Outsourcing
  - ⇒ More complex risk management responsibilities
  - ⇒ Diminishing organic resources
  - ⇒ Reliance on commercial products and processes
  - ⇒ Integrated program management
- IT Performance Measurement
  - ⇒ Results-based mission improvement
  - ⇒ Enterprise-wide process improvement emphasis
    - Performance based acquisition & sustainment
    - Process improvement emphasis

Why Measurement is Important

Measure
Everything
That
Results
In
Customer
Satisfaction



Integrating Qualitative Management



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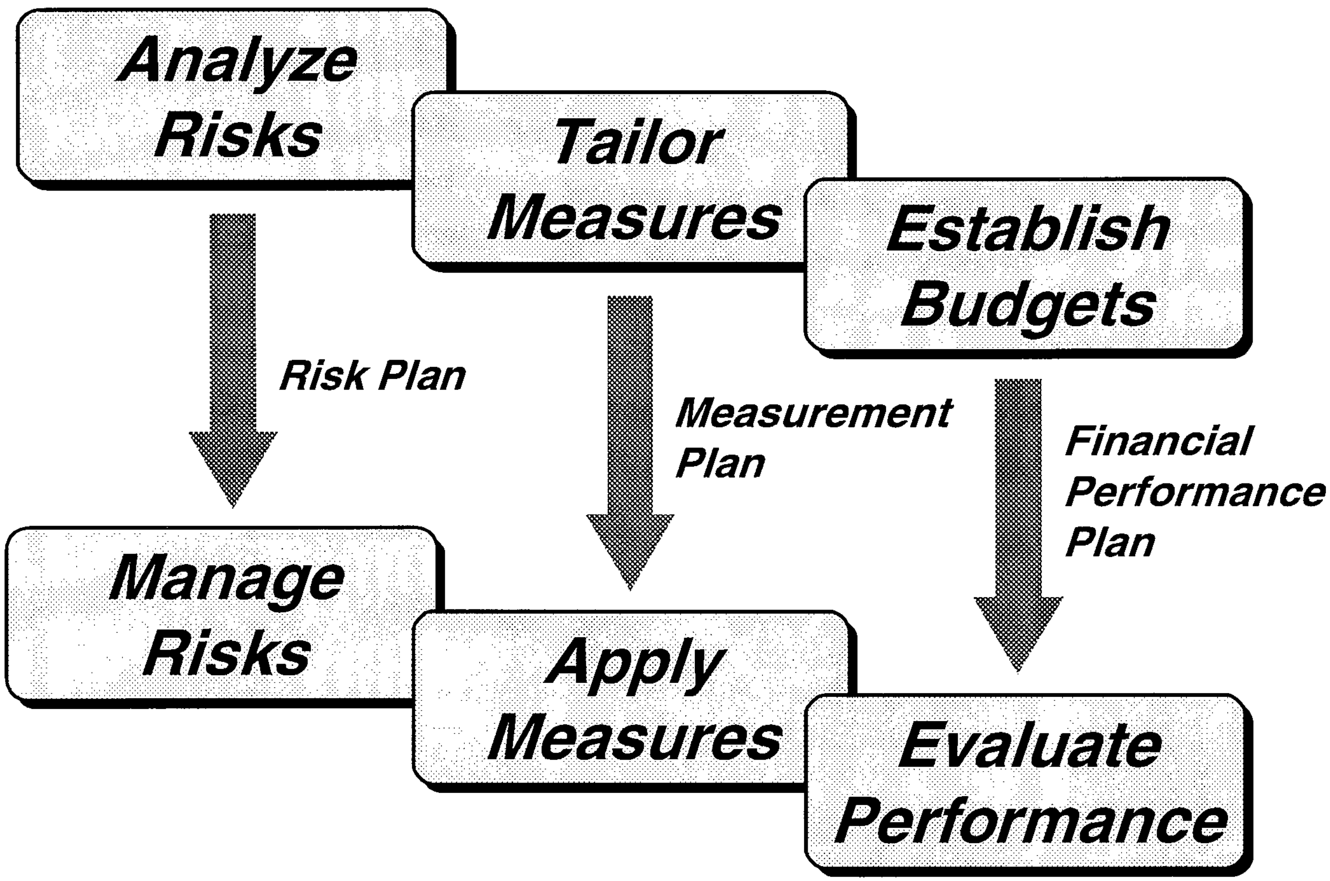
PSM Links Management Functions

Quantitative Management



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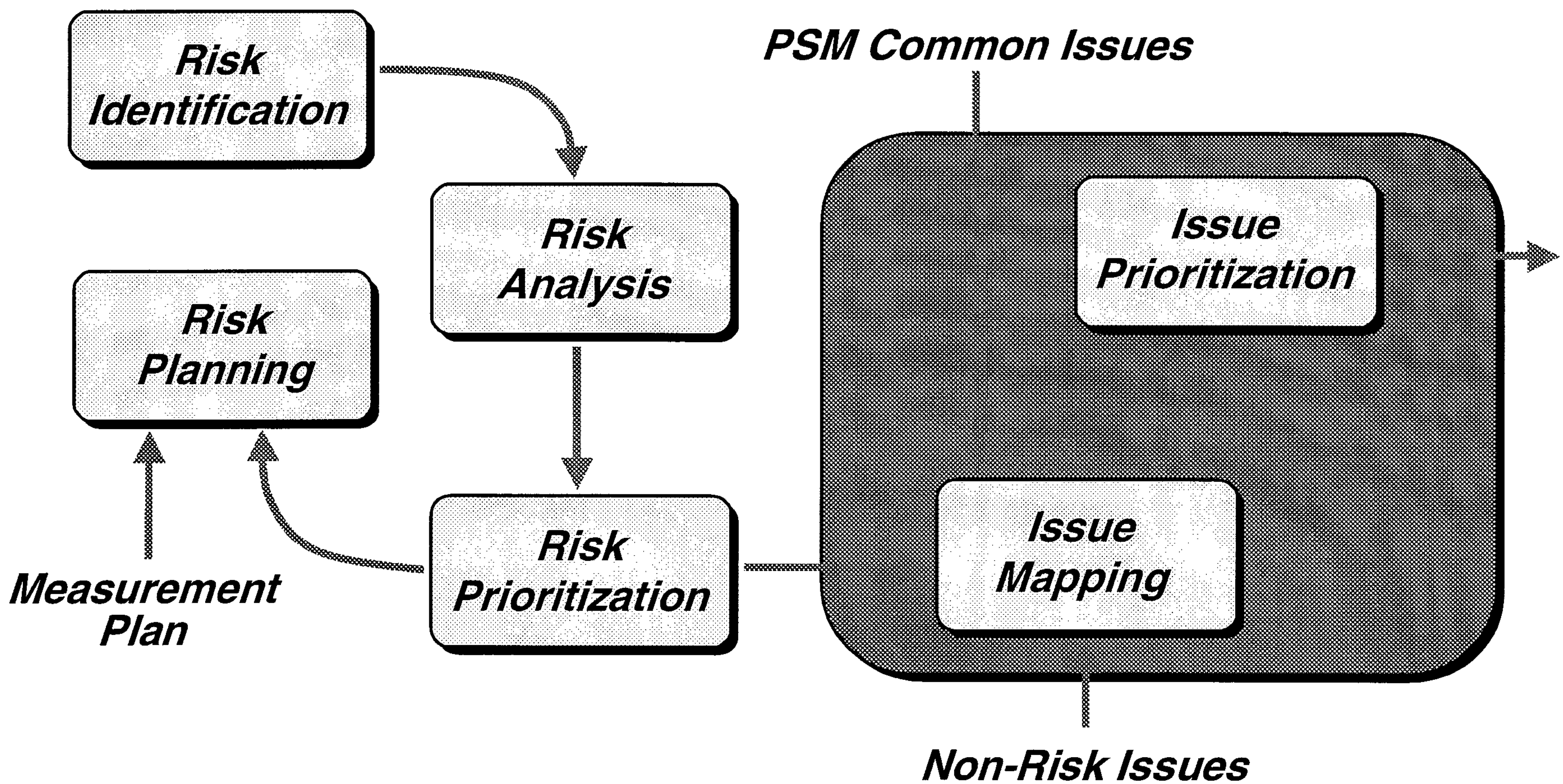
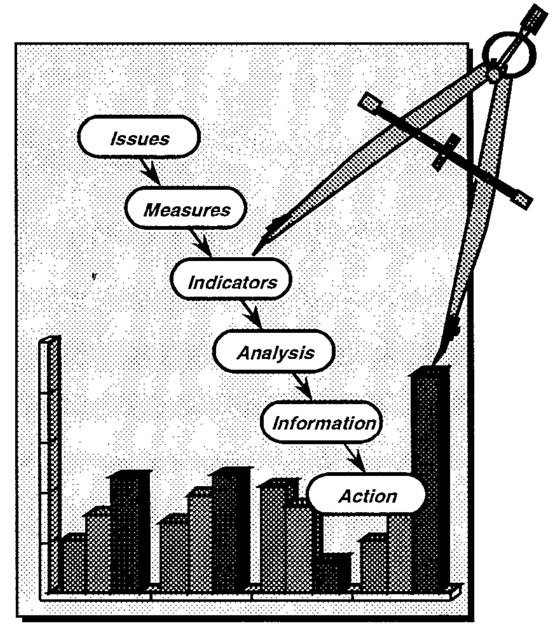
Identify and Prioritize Project Issues

Risk Management relationship to PSM



What Program Managers Need to Know

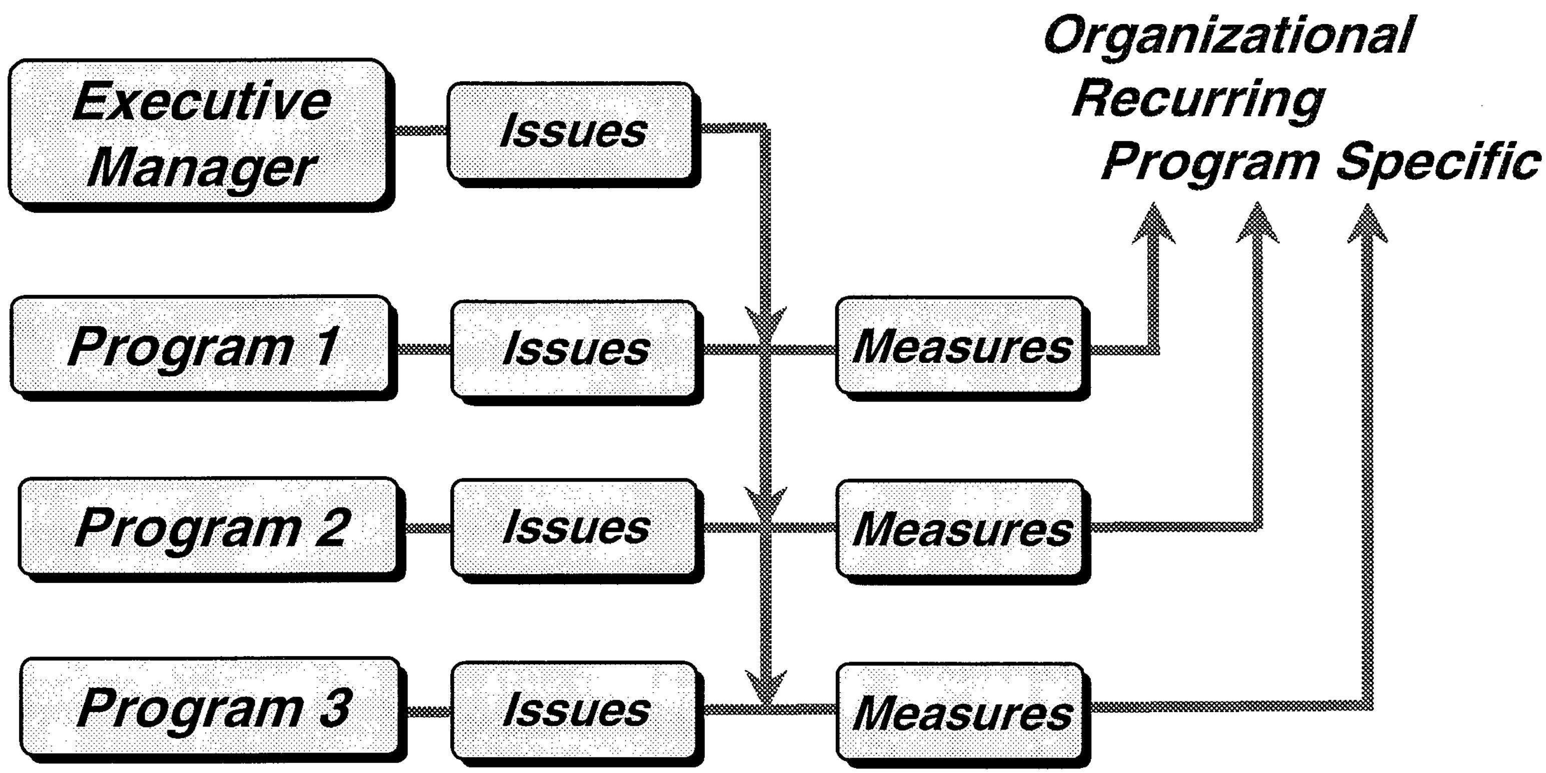
- Is there really a problem?
- How big is the problem?
- What is the scope of the problem?
- What is causing the problem?
- Are there related problems?
- Can I trust the data?
- What should I expect; what will happen?
- What are my alternatives?
- What is the recommended course of action?
- When can I expect to see results?



Issue Mapping

Project Specific Issues	PSM Common Issues
Slipped Schedule Concurrent Activities Critical Dependencies	Schedule and Progress
Changing Mission Objective Unstable Requirements Questionable Size Estimates	Growth and Stability
Reliability Objectives COTS Performance	Product Quality
Fixed Budget Staff Experience Staff Turnover	Resources and Cost

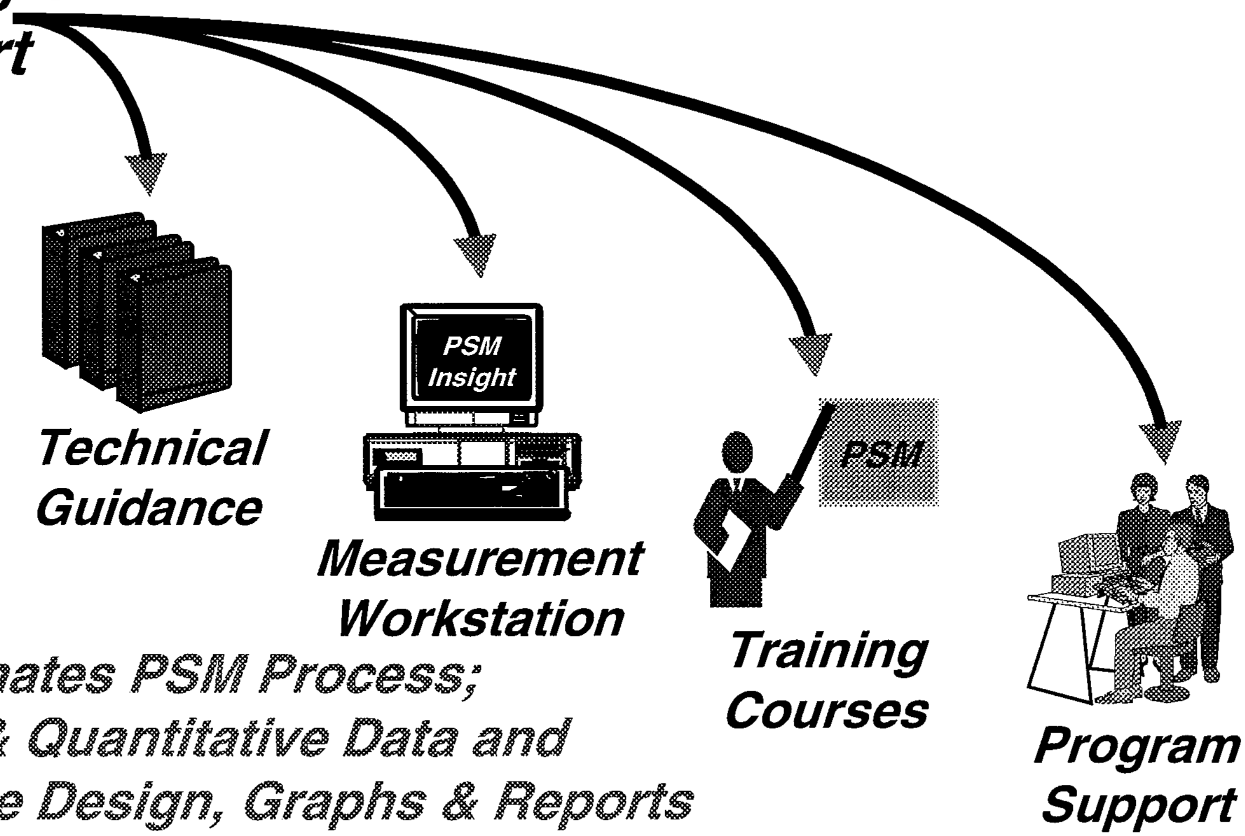
Measurement Across Multi-Programs



- There Are Multiple Sources of Issues -They Must Be Prioritized Together
- Focus Initially On Project Level Measurement
- Standard Organizational Measures Require Consistent Issues & Processes

Updated PSM Product Set

Updated Technical Guidance Version 3
"Insight" Automated Measurement Tool
Revised Training Courses
Program Support

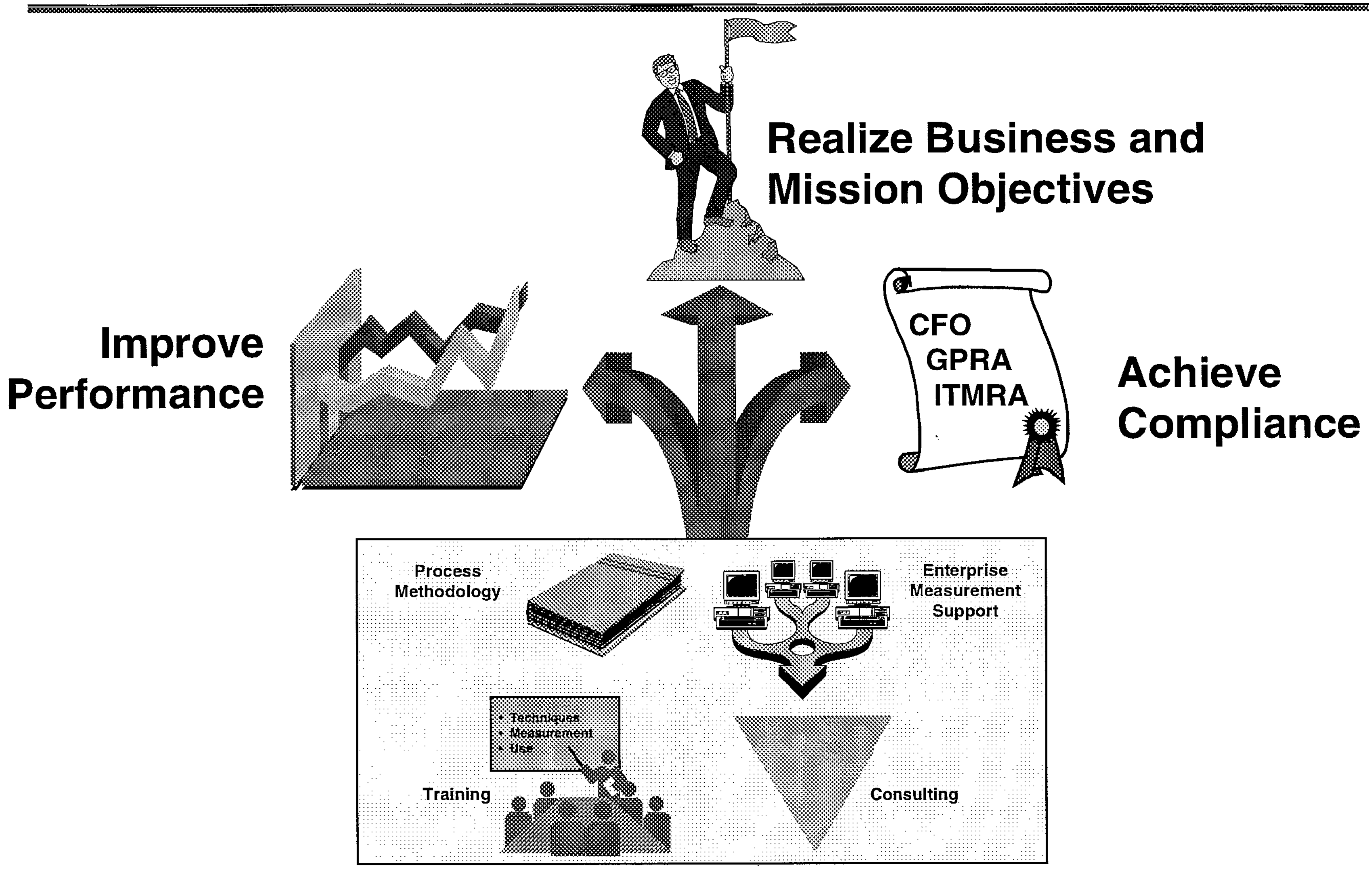


'Insight' tool automates PSM Process;
Provides Context & Quantitative Data and
Tailorable Database Design, Graphs & Reports

PSM Now in Use

- **PSM defines and helps to implement an effective measurement process**
  - ⇒ Provides foundation for quantitative project management and basis for effective decision making at all levels
  - ⇒ Supports DoD SW Acquisition & Measurement Policy; provides basis for integrating all DoD-related measurement resources & efforts, including SEI SW Eng Measurement & Analysis
- **PSM Guidance**
  - ⇒ Developed by measurement professionals from DoD, other Government agencies, and Industry
  - ⇒ Producing measurement guidance and related products, and is transitioning measurement into practice
- **PSM Users' Conference 19-23 July in Breckenridge, CO (see web site at www.psmsc.org)**

Customer Benefits



Summary

ESIP

- Industry & DoD face business challenges associated with software
- ESIP is an cross-cutting program addressing software issues
  - Proven Return on Investment & cost avoidance
  - Accommodates diminishing resources through strategic alliances that leverage the efforts of other programs
- ESIP offers Lessons Learned & opportunities for participation
  - AF R&D in conjunction with Commercial Independent R&D
  - Software Technology Support
    - -- Technology Information Services
    - -- Technology Evaluation & Adoption Services
  - Software Readiness
    - -- Disseminate Software Best Practices
    - -- Provide corporate support for software process improvement
    - -- Transition performance measurement technologies to help programs attain business and mission objectives

E S I P

Additional Questions & Comments

Role of Capability Maturity Models - Facilitate Improvement Efforts

E S I P

Use of Capability Maturity Models (CMMs)

- A CMM provides a foundation for progressive process improvement
  - As a model of industry best practices, serves as standard for evaluating current capabilities and identifying areas that should be improved
  - Provides a structured framework to support the prioritization of actions in a phased approach for improvement
    - Defines the expectation (the “what”) without overly constraining the implementation (the “how”)
- Provides roadmap and building blocks for incremental improvement associated with organizational process maturity
- CMM-based improvement can be achieved in tandem with other improvement efforts, e.g., TQM, ISO 9000 Series

Role of CMMs - Facilitate Improvement Efforts

Conceptual Understanding of the Use of Integrated CMMs

- Integrated CMM supports staged & continuous architecture
  - ⇒ Staging (grouping of key process areas into maturity levels)
    - facilitates a summarization of organizational maturity level based on experience with successful process improvement priorities
    - avails guidance regarding priority & ordering of processes
  - ⇒ Continuous architecture separates process areas
    - facilitates addition of new process areas into the model,
    - guides improvement of any selected process area to any desired level,
    - affords detailed measurability at the process level,
    - leaves it to the organization to decide priority & ordering of processes to improve based on business objectives
    - facilitates, through staging, a summarization of organizational maturity

Process Improvement Business Case

Why Focus on Process Improvement?

- Establish a common understanding of the customer's requirements between the customer and the project team
- Establish reasonable plans for performing systems and software engineering and for managing projects
- Provide adequate visibility into the actual progress so management can take effective actions when the project's performance deviates significantly from plans
- Ensure the integrity of the project's products are established and maintained throughout the project's life cycle; remove defects early and efficiently from work products
- Select and manage qualified subcontractors

Process Improvement Business Case

Value of Enterprise-wide Process Improvement

- **Establish organizational inter-departmental process improvement**
  - Develop and maintain a usable set of process assets that improve process performance across the projects being developed & sustained
  - Ensure software engineering group actively participates with other engineering groups to satisfy customers' needs effectively and efficiently
  - Integrate all software engineering & systems engineering activities to produce correct, consistent products effectively & efficiently
  - Integrate engineering and management activities into a defined process that is tailored from the organization's standard process and related process assets for each project
- **Develop common language, skills & knowledge of the individuals so they can perform their roles effectively and efficiently**

Process Improvement Business Case

Use of Capability Maturity Models (CMMs)

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- CMM-based improvement can be achieved in tandem with other improvement efforts, e.g., TQM, ISO 9000 Series

Process Improvement Business Case

Benefits of Continuous Process Improvement

- Improved understanding of how the organization develops and delivers software-intensive systems
- Increased control of costs, schedule & product quality
  - Reduced development cycle time by reducing rework
  - Reduced schedule variance
  - Increased predictability and control of software and product quality
  - Enhanced risk management decisions based on quantitative data
- Improved environment for management and workforce
  - Ability to make cost-benefit tradeoffs of applicable technologies/processes
  - More time available to spend on problems requiring creative energy
  - People feel more empowered to propose process improvements for organization-wide benefit
- More competitive organization
- Satisfied customers

Process Improvement Business Case

Characteristics of A Mature Process

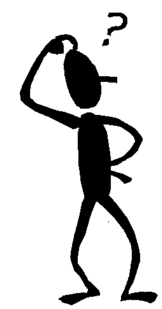
- Defined and documented
- Clear definition and understanding of roles and responsibilities throughout project and organization
- Supported visibly by management
- Used and is consistent with the way work actually gets done
- Well controlled - fidelity is audited and enforced
- Measured
- Supported by technology when appropriate
- Living & evolving (continuous improvement)

Process Improvement Business Case

Supporting Business Objectives

For a process improvement initiative to be successful, it must be tied to the organization's business objectives

- What are the organization's highest priorities?
- What business consequences have resulted from weak or ineffective processes?
- What action is being taken to correct the cause?
- How is the process improvement initiative seen to:
  - support the organization's business objectives?
  - tie into the organization's overall focus on quality management?



Process Improvement Business Case

Business Objectives - Examples

- Reduce delivery time and schedule variance
- Enable effective communication between separate business units
- Reduce system errors that are discovered by customers
- Provide demonstrated Return on Investment
- Increase quality of products
- Increase productivity
- Increase customer satisfaction

SPAWAR

SPAWAR

Ordnance on Target - With the Speed of Command

Captain Rich Zajicek, USN
Deputy Program Executive Officer
Space, Communications & Sensors

17 June 1998

Our Mission

SPAWAR is the Navy Acquisition Command responsible for systems which move information to the Warrior

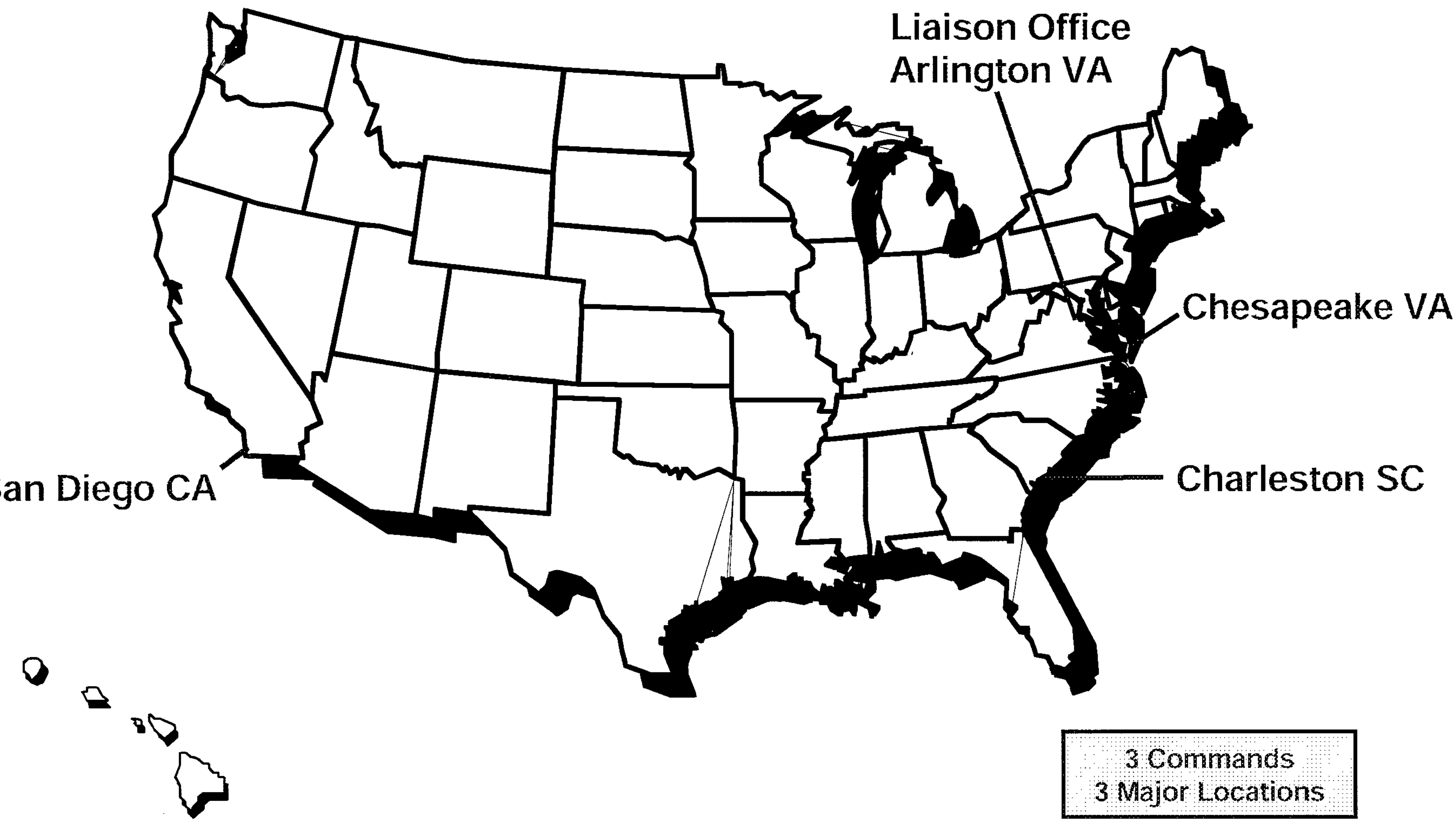
- Providing products
  - Physical systems/equipment
  - Architecture, standards, systems integration plans, concepts of operations
- Integrating all information products, including those developed by other systems commands and agencies outside the Navy

SPAWAR

Our Mission

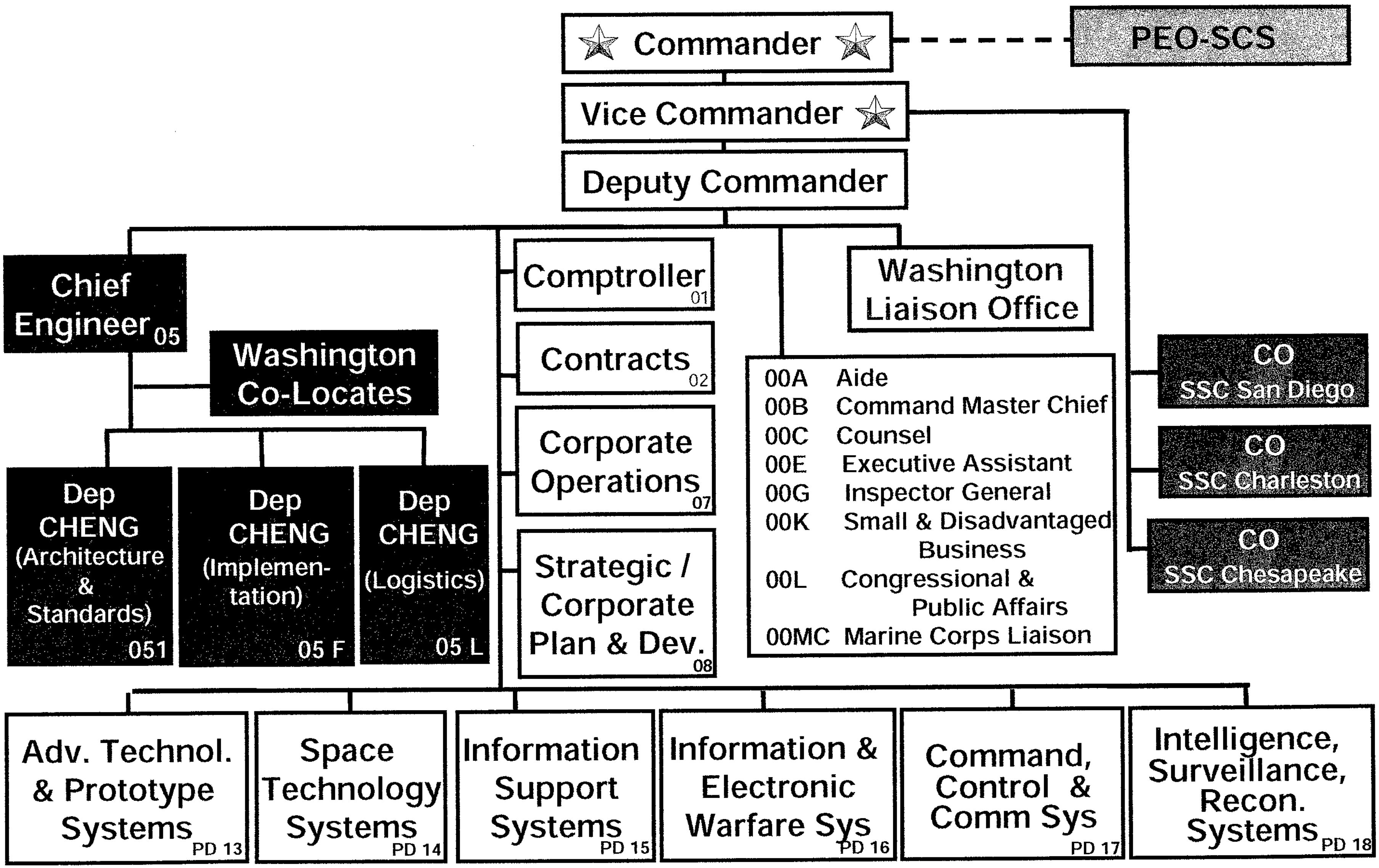
- To provide naval commanders a decisive warfare advantage through the development, acquisition, and life cycle management of effective and responsive:
  - Battle Management Systems
    - Software Applications, Computers, Displays
  - Undersea, Terrestrial and Space Sensors
    - Satellites, Underwater Sensor Arrays, Navigation and Weather Systems
  - Information Transfer Systems
    - Communications Systems, Radios, Satellite Ground Stations, Antennas, Switches
  - Information Management Systems
    - Infrastructure (LAN's, Routers, Hubs), Non-Tactical Software

Corporate SPAWAR



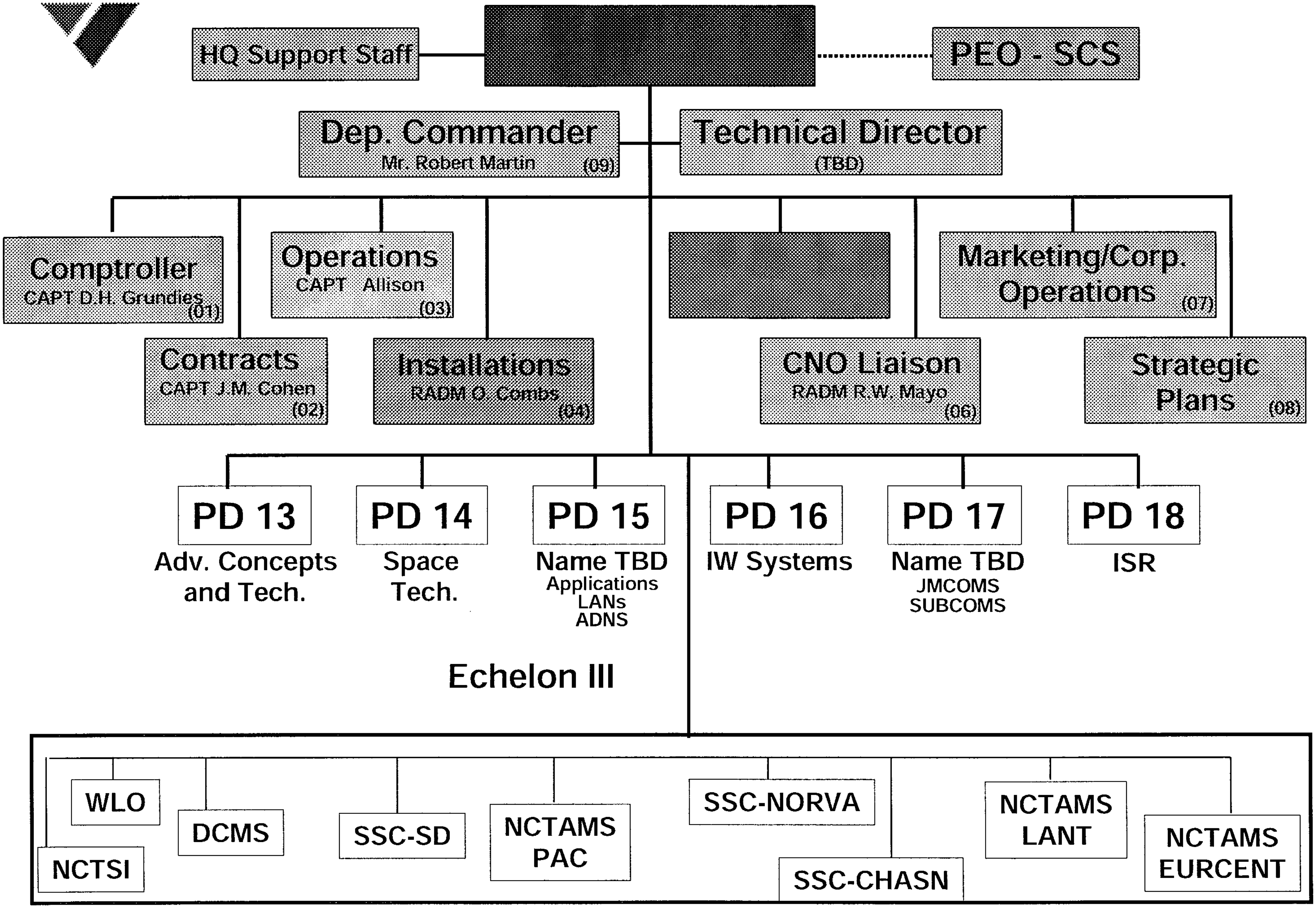
3 Commands
3 Major Locations

Space and Naval Warfare Systems Command



SPAWAR

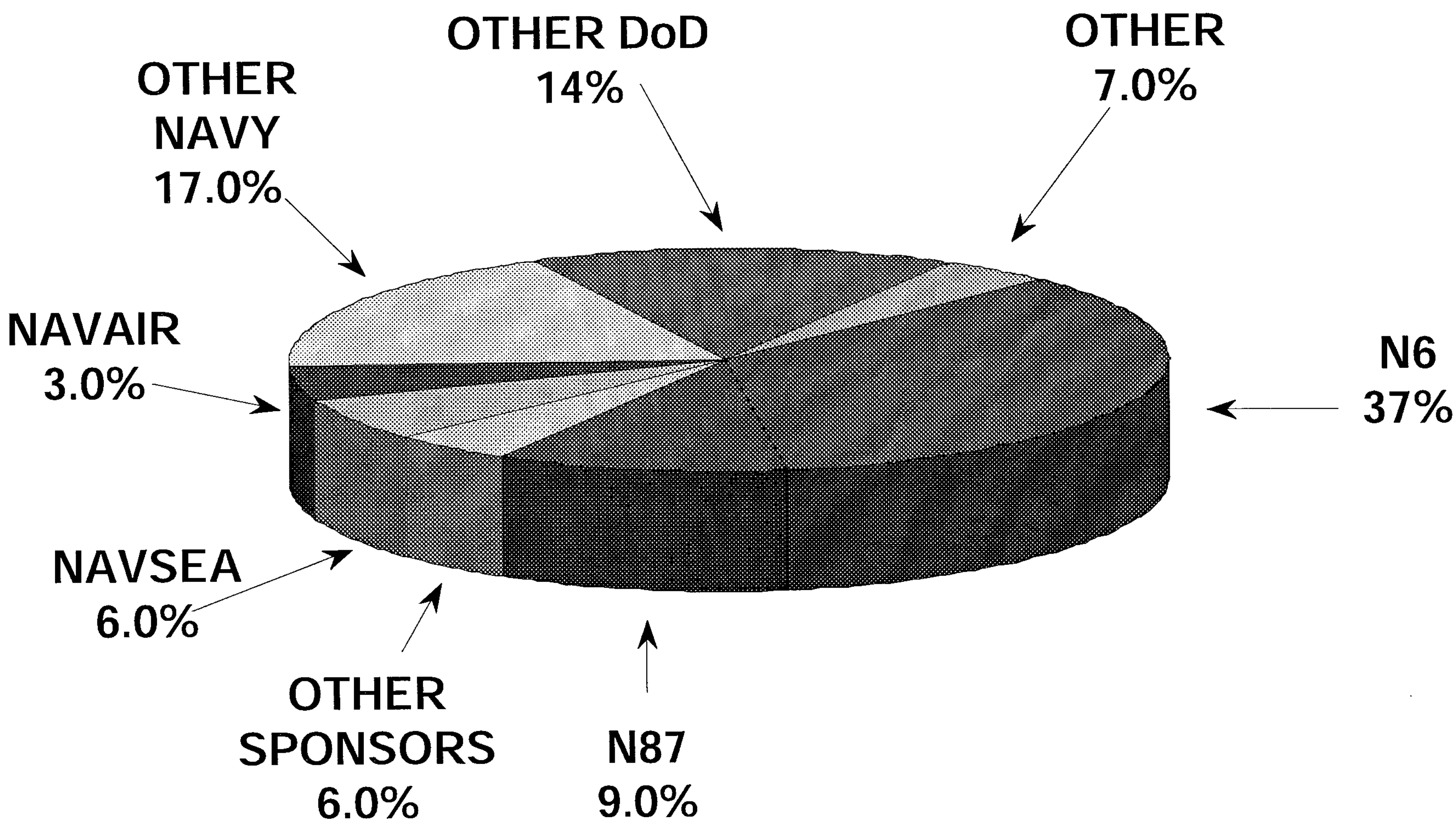
Echelon II Headquarters



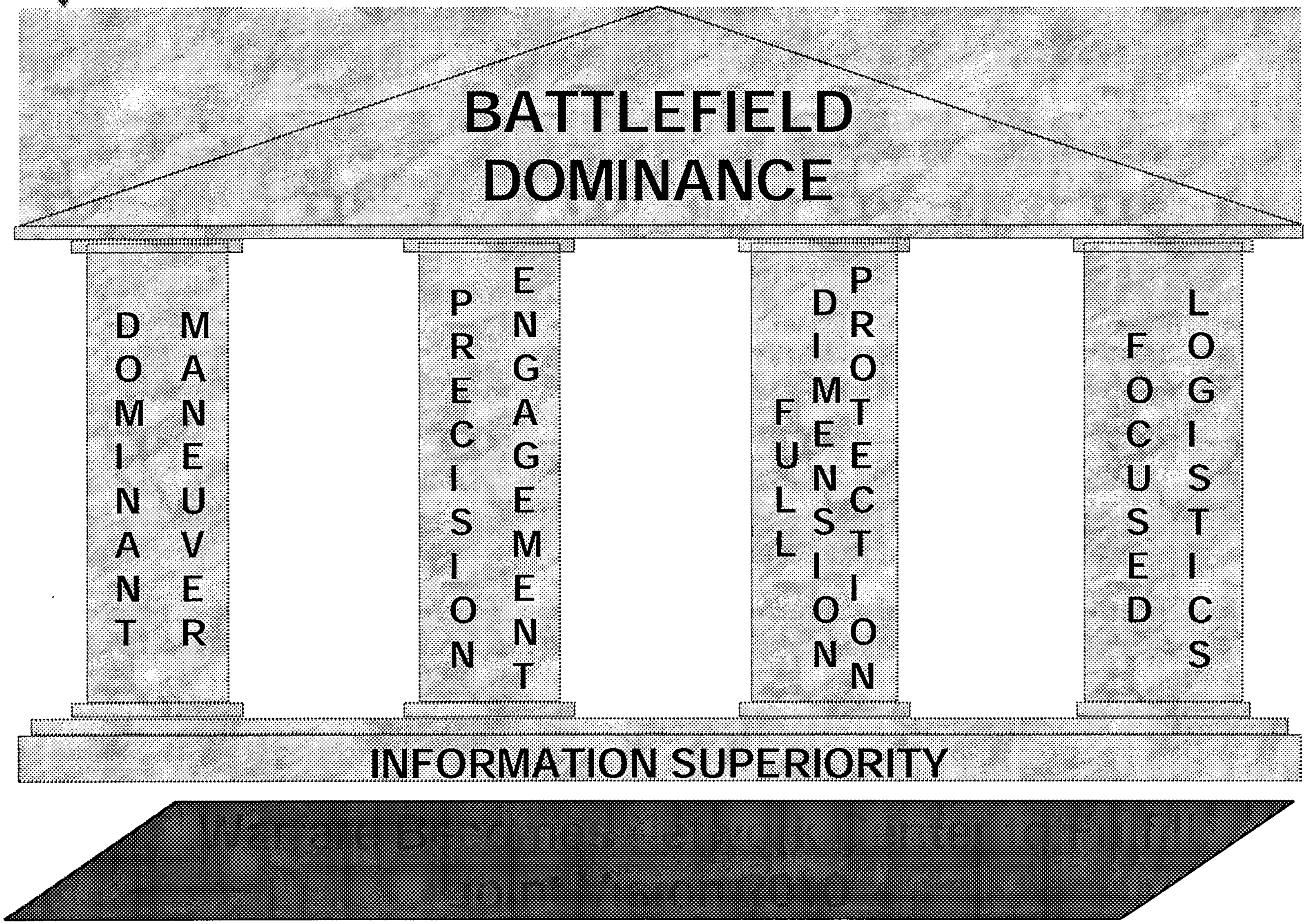
SPAWAR

Our Sponsors

Total Corporate - $3.549B
(Includes SSC-SD, PEO & Other Customer Funds)

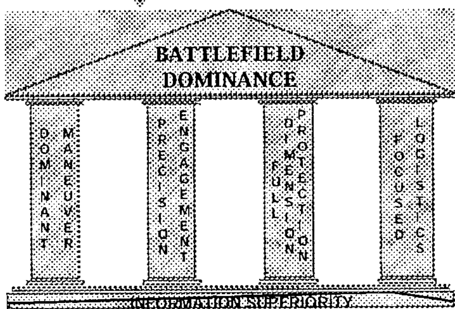


Joint Vision 2010



SPAWAR

IT-21 is Part of the Solution



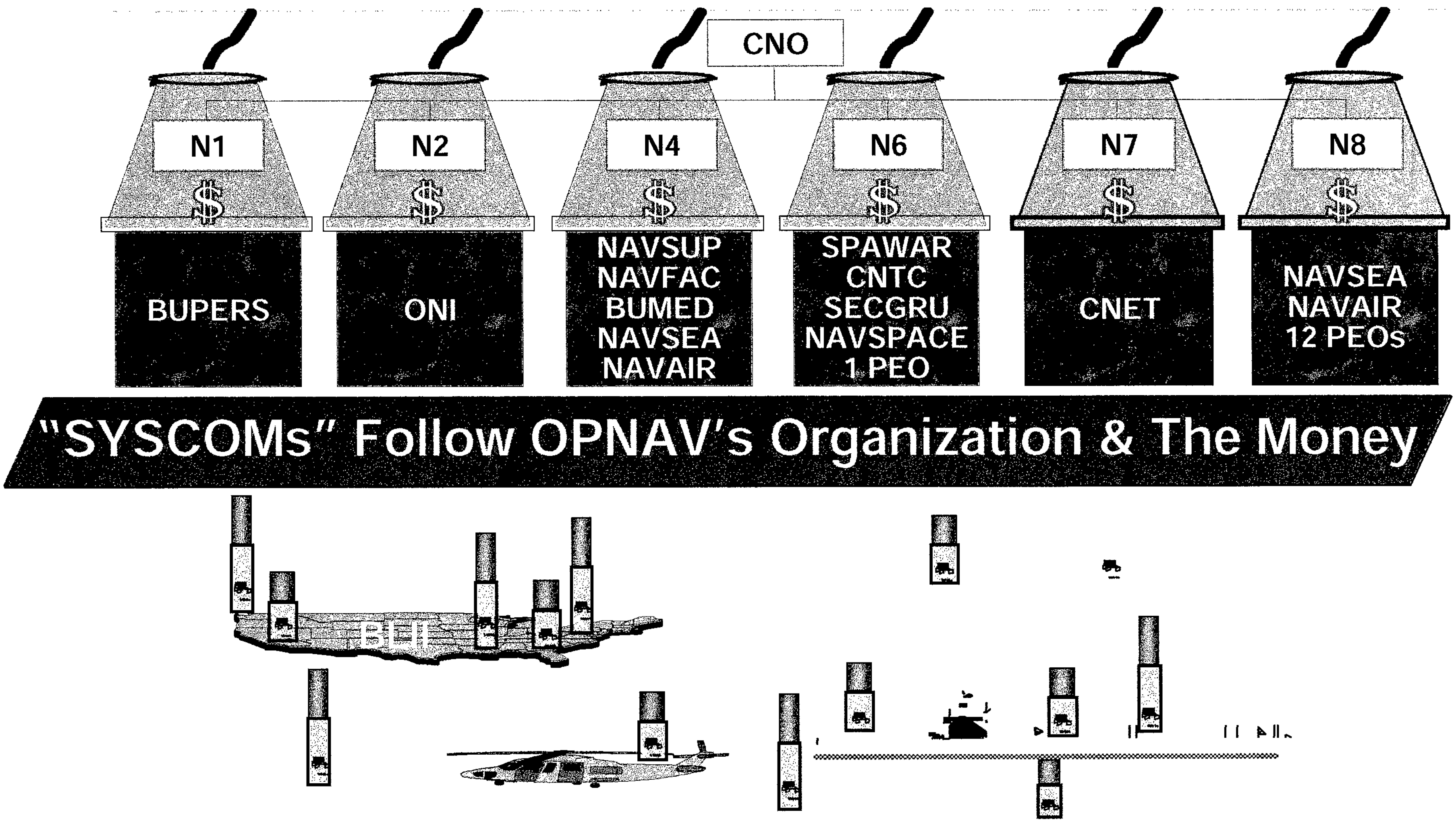
- "Ordnance on Target" with "Speed of Command" requires a strategy to do this

Not Included in IT21	Integrate Tactical Data Links to common backbone & Interface Weapons Control to common backbone
	Integrate C4ISR Applications & Data
	Integrate Combat Support Applications & Data

IT21

Infrastructure Foundation:
SATCOM / MANs / LANs / PCs / ATM Backbone / Information Assurance

Today's Paradigm: The Money Flow & The Results



The Result ...
Stovepipes **EVERYWHERE!!!**

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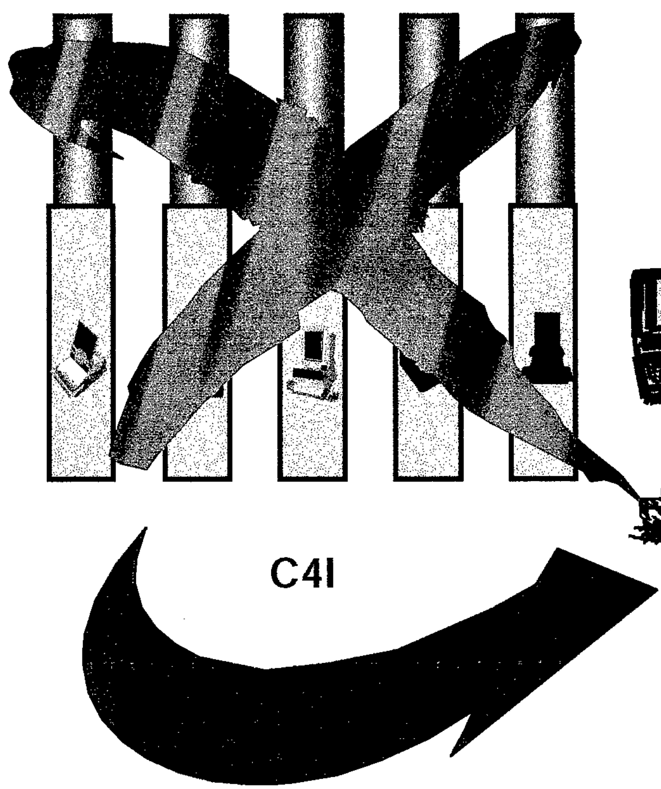
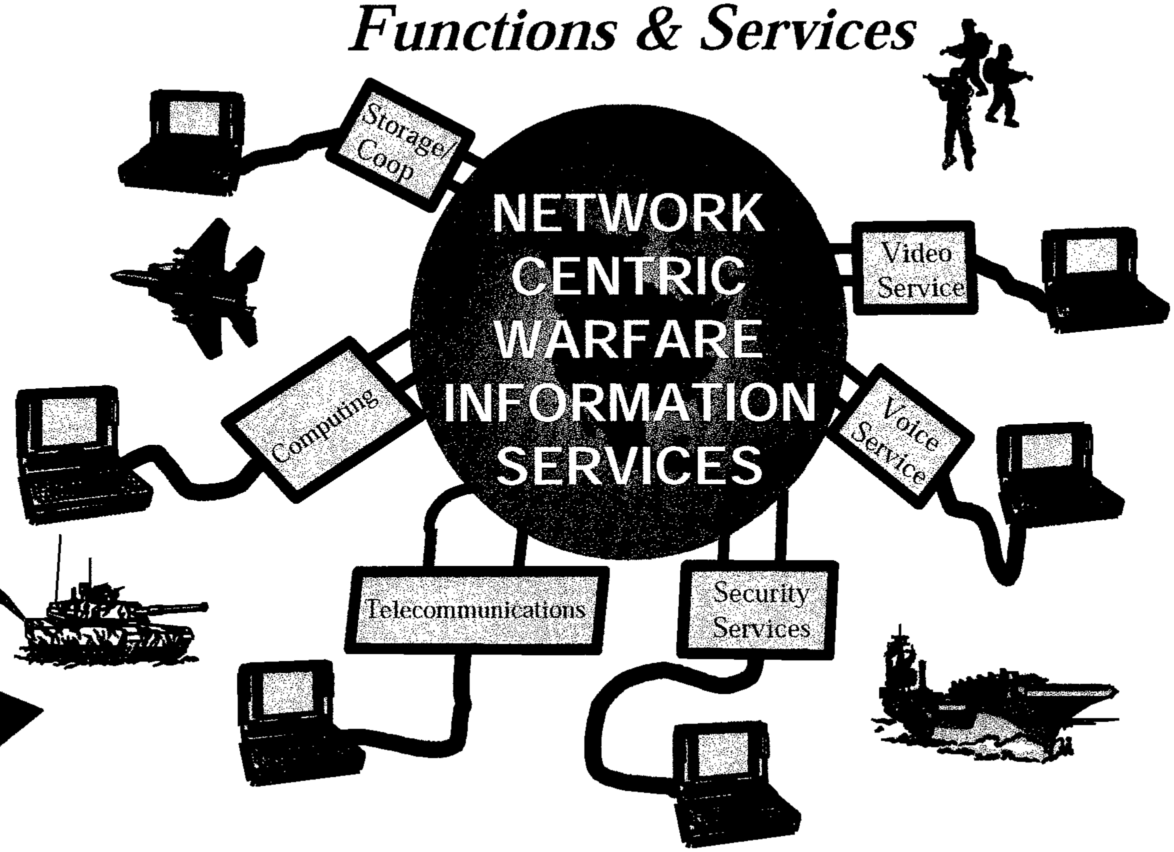
To Achieve Joint Vision 2010 We Must Change the Paradigm

From:
Providing *Interfaced* Stovepipe *Systems*



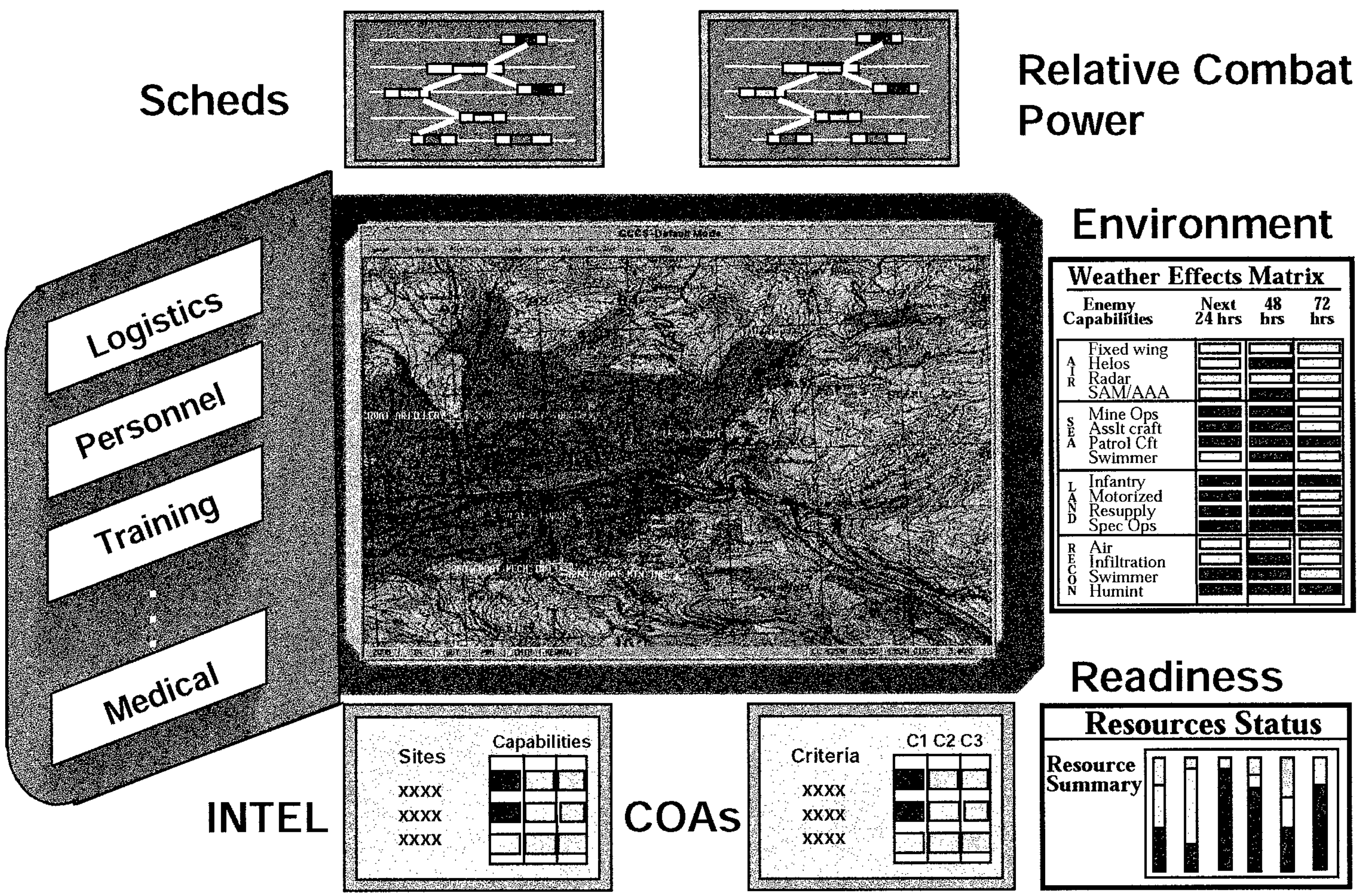
To:
Providing *Integrated* Information *Functions & Services*



Anywhere, Anytime, Any Mission

The "Backplane" Enables Solving The Real Integration Problem:

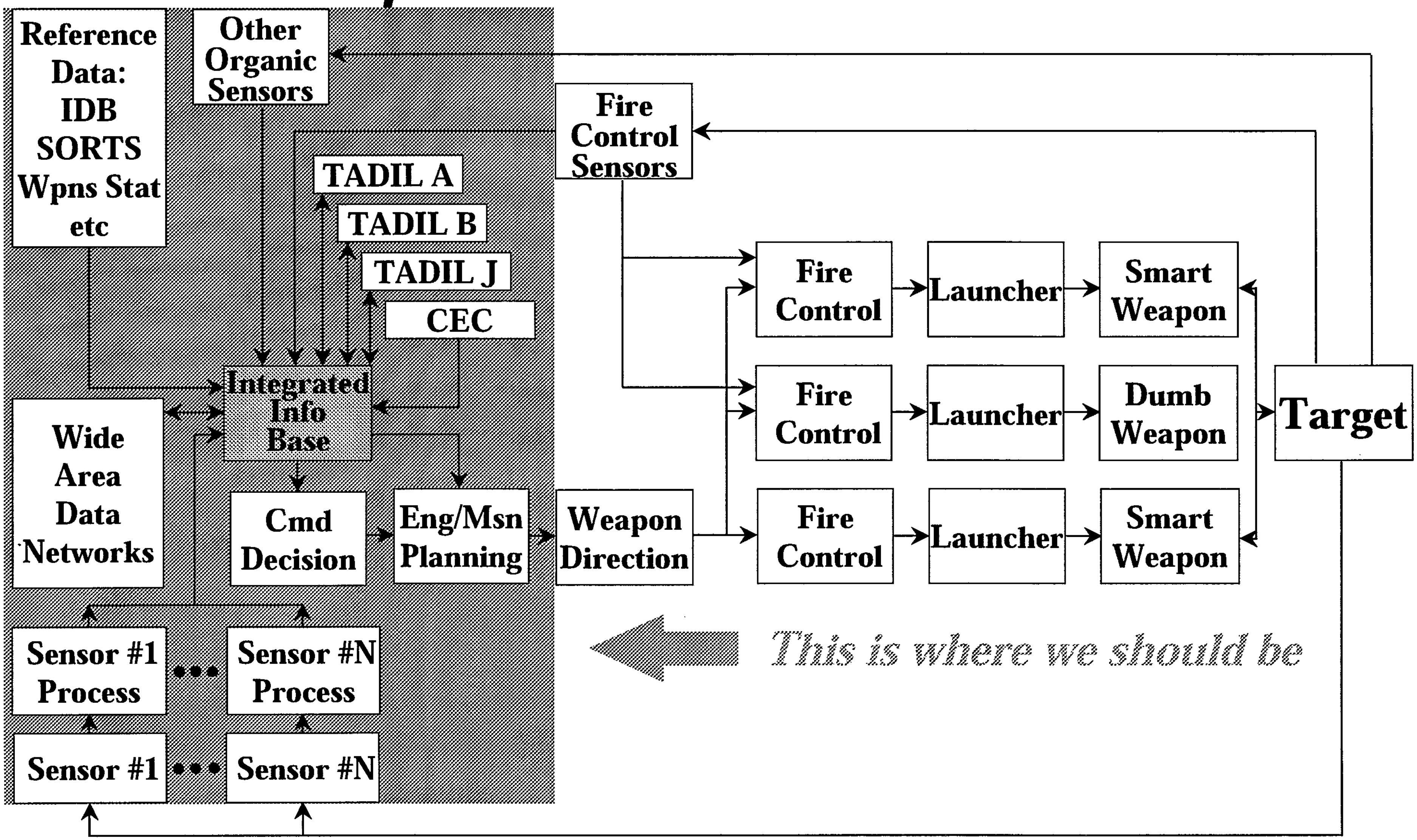
Access to Integrated Information from a Single Window



Information Integration is Our Future!!!

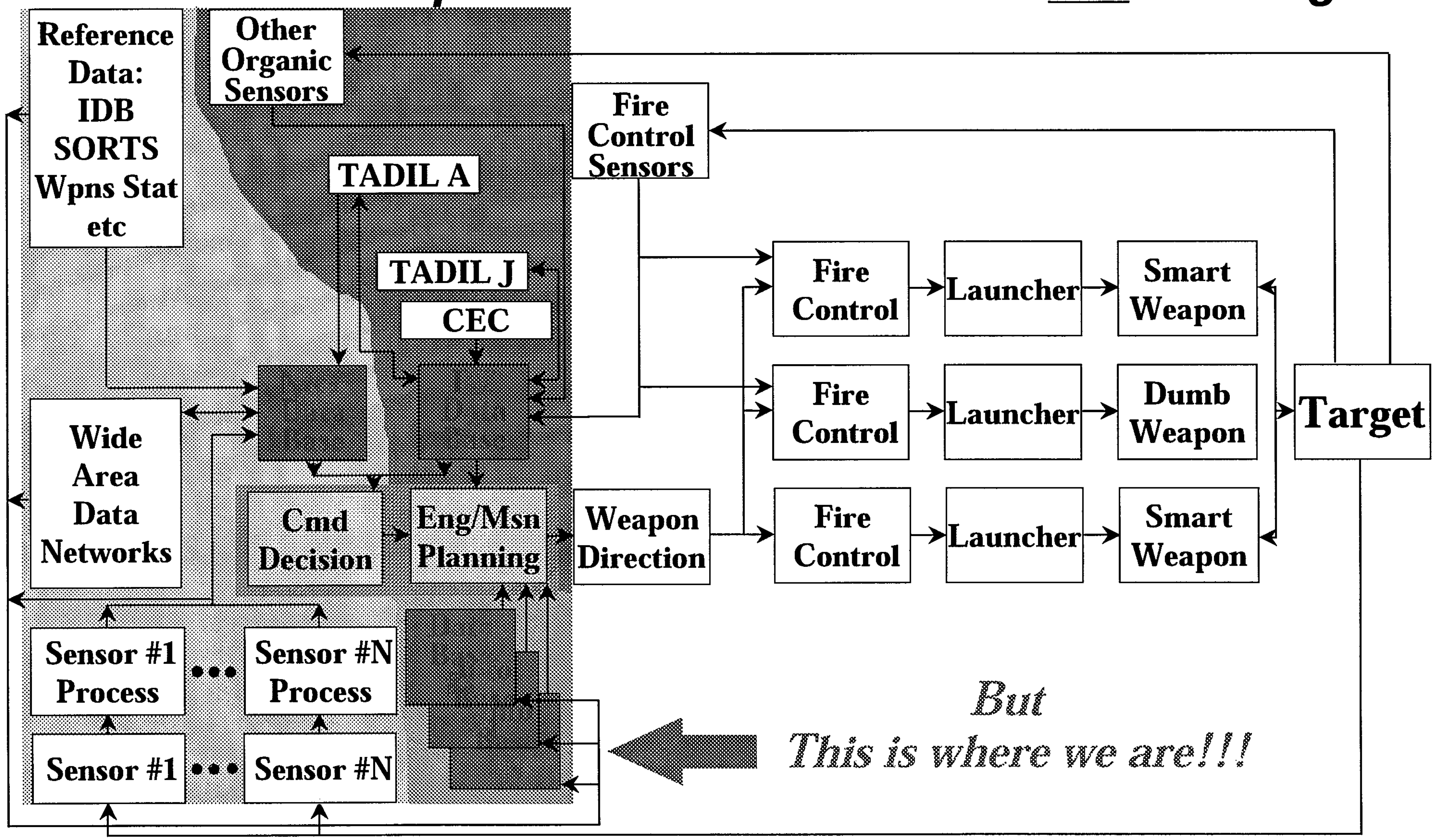
Putting "Ordnance on Target" with "Speed of Command"

The Required Functions: How It Should Work



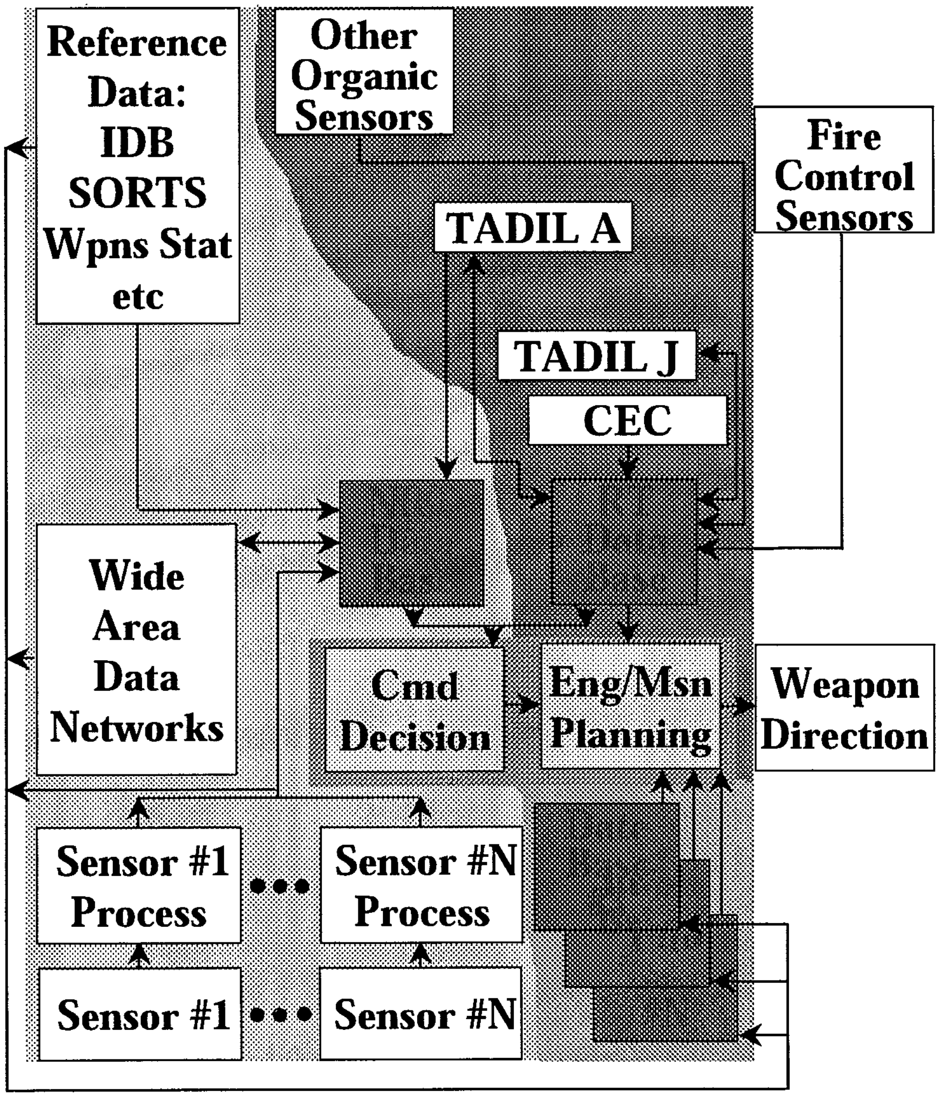
Putting "Ordnance on Target" with "Speed of Command"

The Required Functions: How It Is Not Working



Putting "Ordnance on Target" with "Speed of Command"

This Is Where We Are!!!



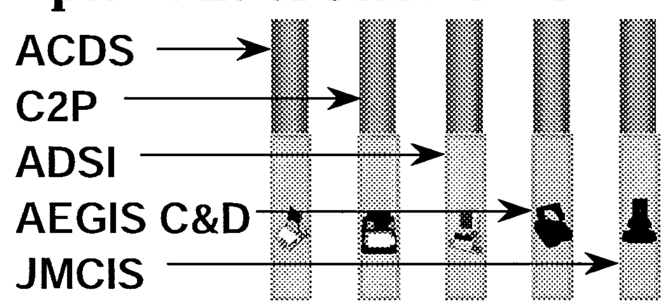
- **Each red area is the result of building systems vice end-to-end capability**

No shared information	Different standards
Different software for same functions	Different architectures

- **Today's examples:**

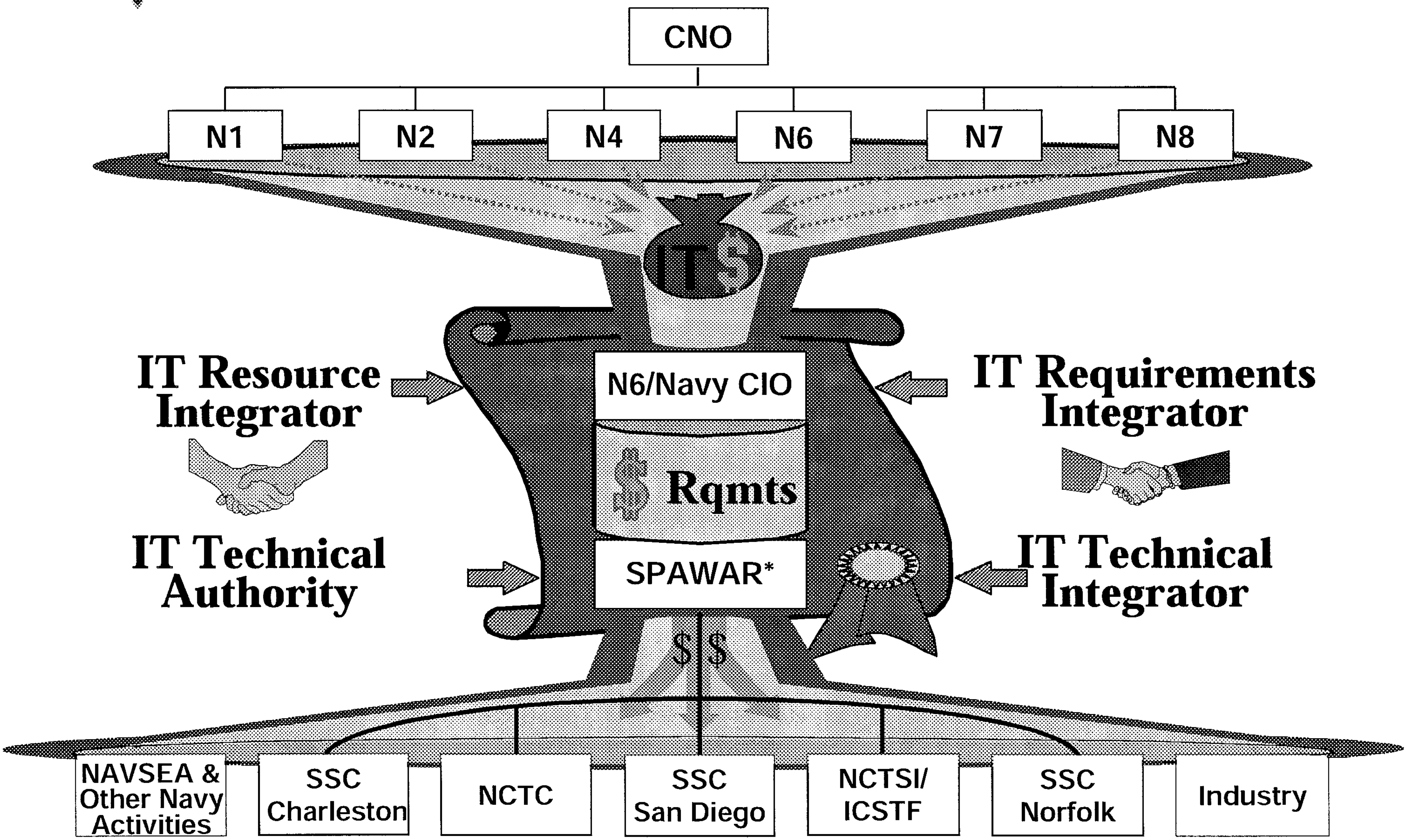
NRT Info Base	GCCS, JMCIS
RT Info Base	ACDS, CDS, 642B, ADSI, C2P AEGIS C&D (many baselines)
Info Base #3	ATWCS
Info Base #4	TAMPS
Info Base #N	TEAMS, TERPES, APS, etc.

- **Symptomatic of Stennis BG**



We build interfaced, stovepiped systems with non-interoperable data bases

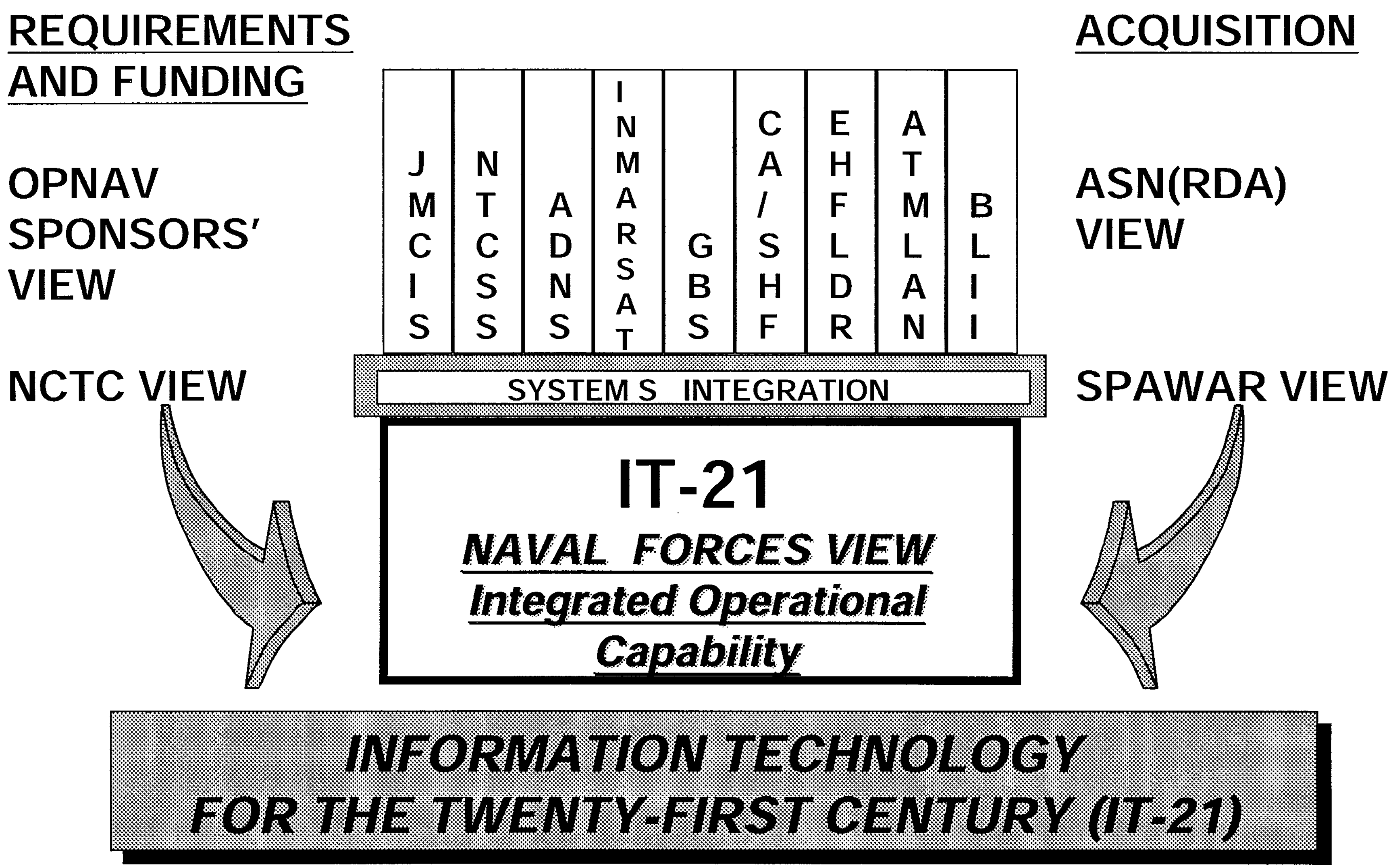
The Required Process & Authorities To Deliver End-to-End Capability



*Includes Tactical Data Links

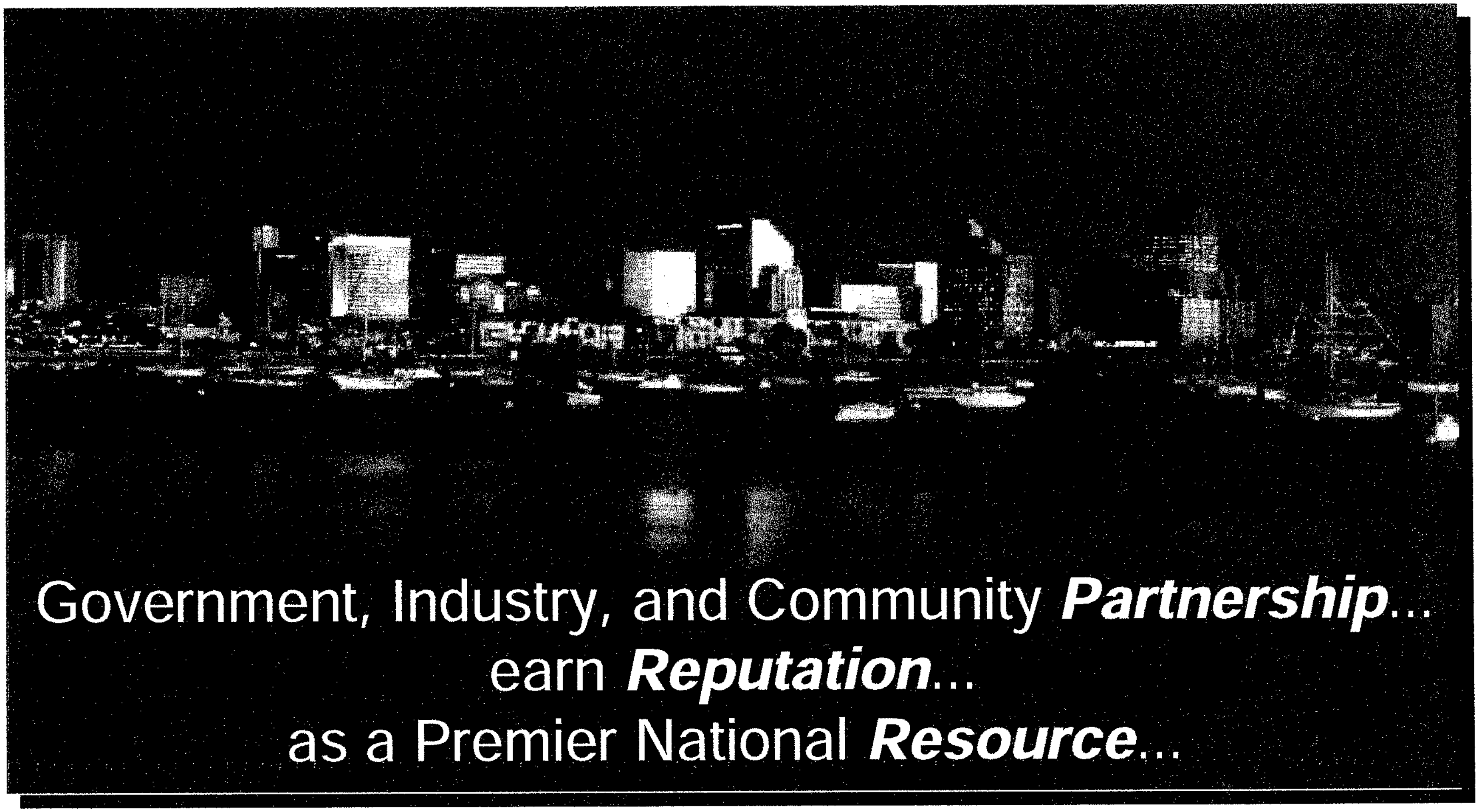
SPAWAR

Summary



SPAWAR

Our Vision



Naval Aviation:
"Leveraging Information Technology for the 21st Century"

Rear Admiral "Carlos" Johnson

Aviation Plans and Requirements

Avionics for the 21st Century

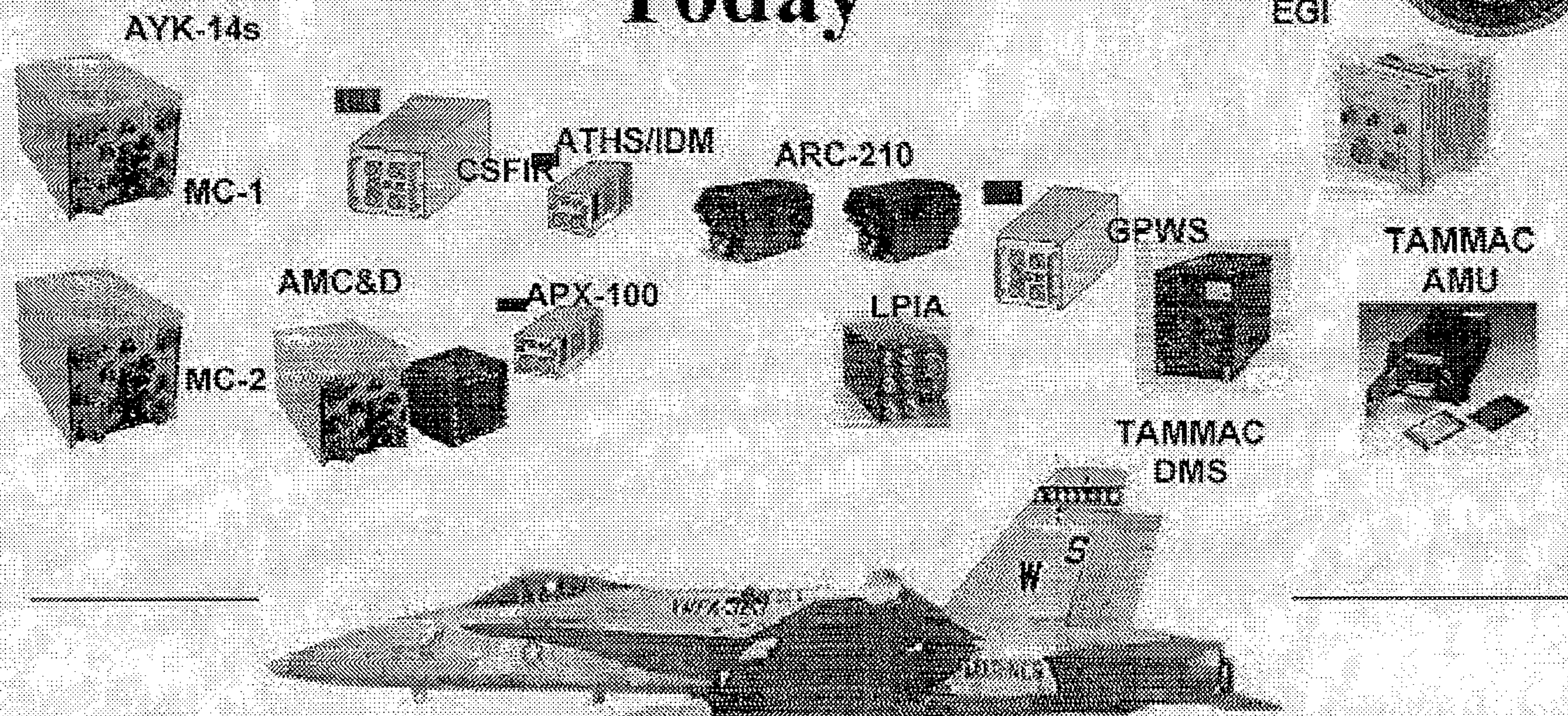
- Trends
- Goals
- Avionics today
- Revolutionize avionics

Avionics Trend

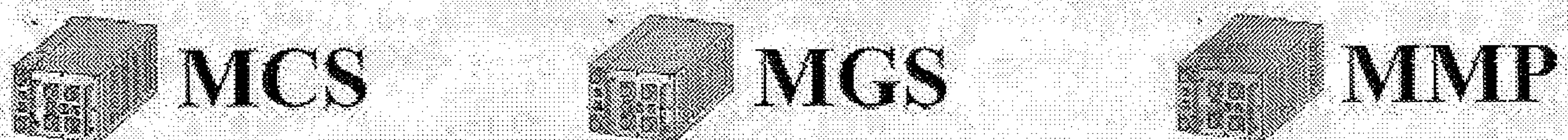
- "While 1% of the cost of a World War I combat plane was devoted to electronics, in World War II it was 10%, in the Vietnam War it was 35%, and now it's 45%."

Norm Augustine
Chairman, Lockheed Martin

Federated Avionics Today



Where We Are Going Tomorrow

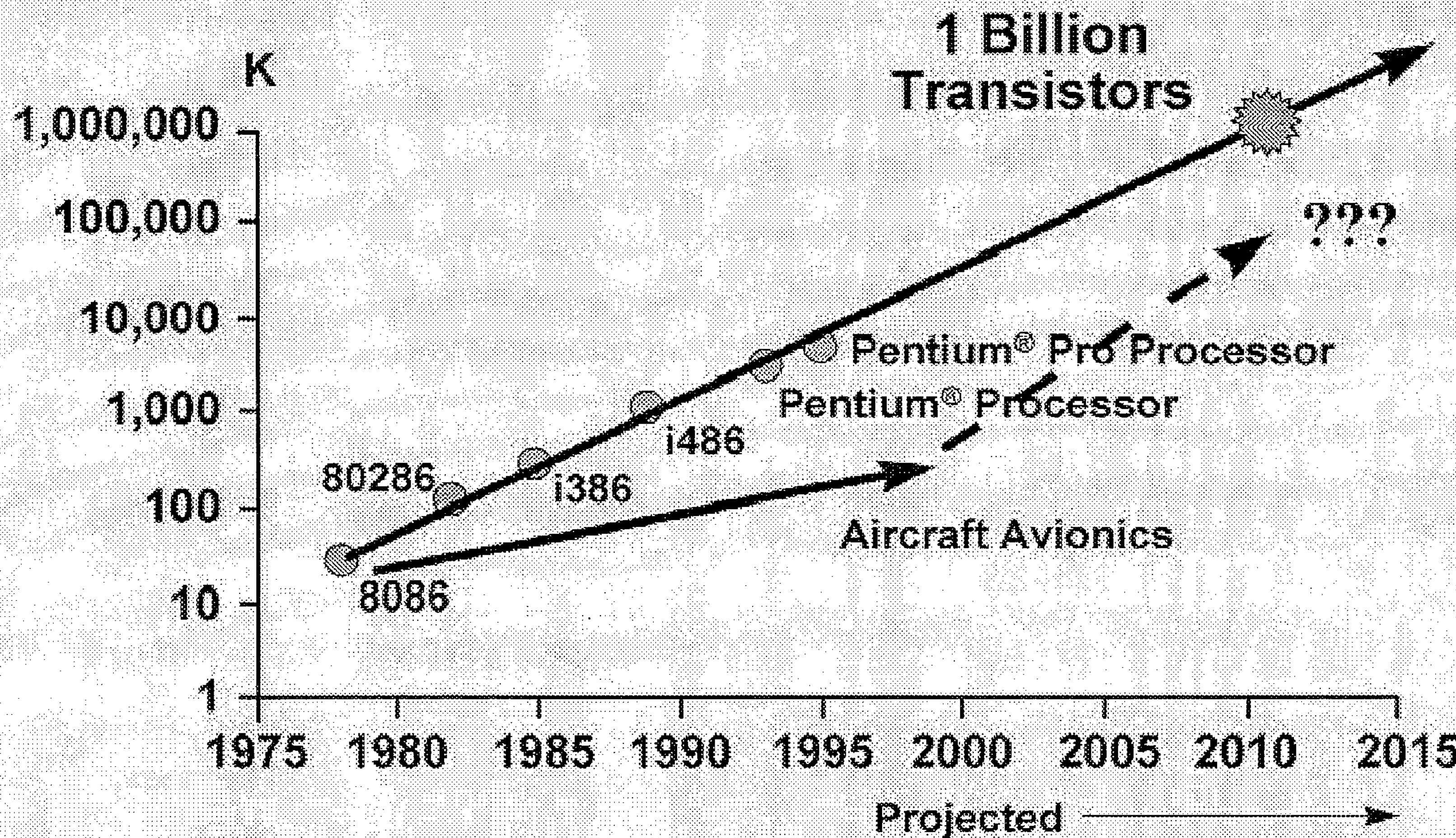


Goals

- Increase battlespace awareness
- Emphasize functionality of systems
- Leverage Commercial/Government Off the shelf Technology
- Plug and Play... then throw away
- Reduce life cycle costs
- Better, faster, cheaper

"We must leverage off the information revolution. If we don't our adversaries will. We must give the warfighter of the 21st century the tools to go in harm's way and prevail."

Defying Moore's Law



"Military aircraft avionics have not kept pace with commercial Information Technologies"

"Revolutionized" Avionics System Design is Needed

- Extremely capable, but
  - Establish standards for form, fit and function
  - Clearly define plug and play and open architecture
  - Modular, reusable "outerware" and software
  - New technology easily/affordably inserted to upgrade capability

Transition from "legacy" systems will take time and must be made affordable

Example of Strategy

(AN/ARC-210(V) Acquisition Reform Initiative

- Recognize Navy "standard" tactical airborne radio
- Long term partnership with Rockwell-Collins
  - 5 year CJ&A for sole source
- Leverages existing commercial technology
  - Reduces system cost by 19%
  - Increases reliability by 120%
  - Eliminates obsolescence
  - Provides viable path for future growth
- Five year failure-free reliability improvement warranty
  - Mitigates government risk
  - Guaranteed MTBF in the fleet
  - Eliminates "I" level maintenance requirements
- Total five year cost avoidance: $65M

Summary

- Affordable strategy for legacy management
- Proactive modernization plan for the 21st century
- DoD and industry need to work together to deliver the most innovative and cost effective approach
  - Develop once and install across many platforms
  - Leverage other PMA/PMW/other services' investments
  - Establish long term business partnership with industry
    - » Maximize benefit of large procurement actions
    - » Leverage of industry investments
    - » Rapid infusion of commercial technology
    - » Significant reduce life cycle costs

NAVY SCIENCE AND TECHNOLOGY PROGRAM

THE RESOURCE SPONSOR PERSPECTIVE

HUGH E. MONTGOMERY, JR.

DIRECTOR, SCIENCE AND TECHNOLOGY DIVISION (N911)

SCIENCE & TECHNOLOGY DIVISION (N911)

- S&T RESOURCE SPONSOR
  - POM INVESTMENT STRATEGY
  - PROGRAM DEFENSE
- S&T REQUIREMENTS
  - ROUND TABLES
  - REQUIREMENTS DOCUMENTATION
  - TECHNOLOGY INITIATIVES GAME (TIG)
- TECHNOLOGY TRANSITION
  - ATD PROCESS
  - INTEGRATED PRODUCT TEAMS

LOOKING TO THE FUTURE

- FUTURE IS POTENTIALLY VERY DIFFERENT FROM PRESENT
- AFFORDABILITY WILL BE A MAJOR DRIVER
  - NEED NEW WAYS OF DOING BUSINESS
- DOD/CONGRESSIONAL PROCESS MAKES NONLINEAR FUTURE DIFFICULT TO ACCESS
- EFFECT OF BALANCED BUDGET UNKNOWN

SCIENCE & TECHNOLOGY

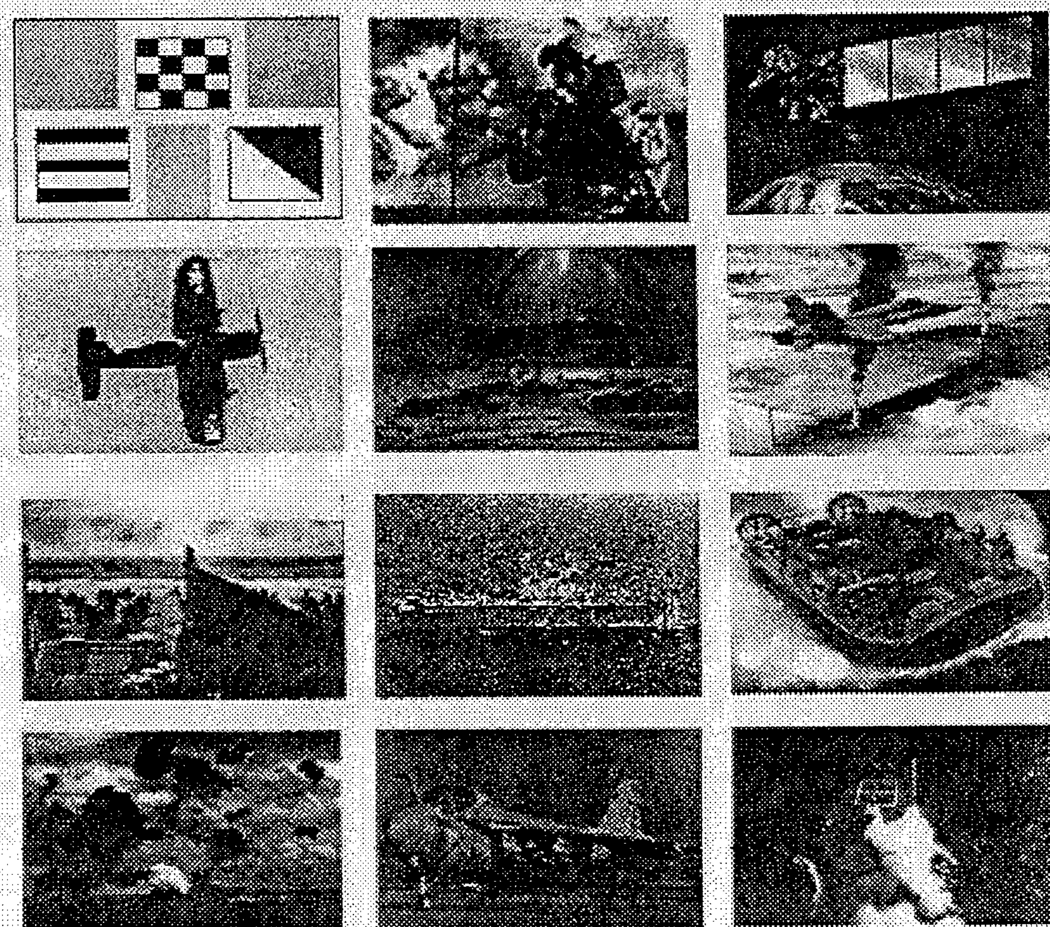
WWII | Vietnam | Desert Storm

Command, Control & Surveillance

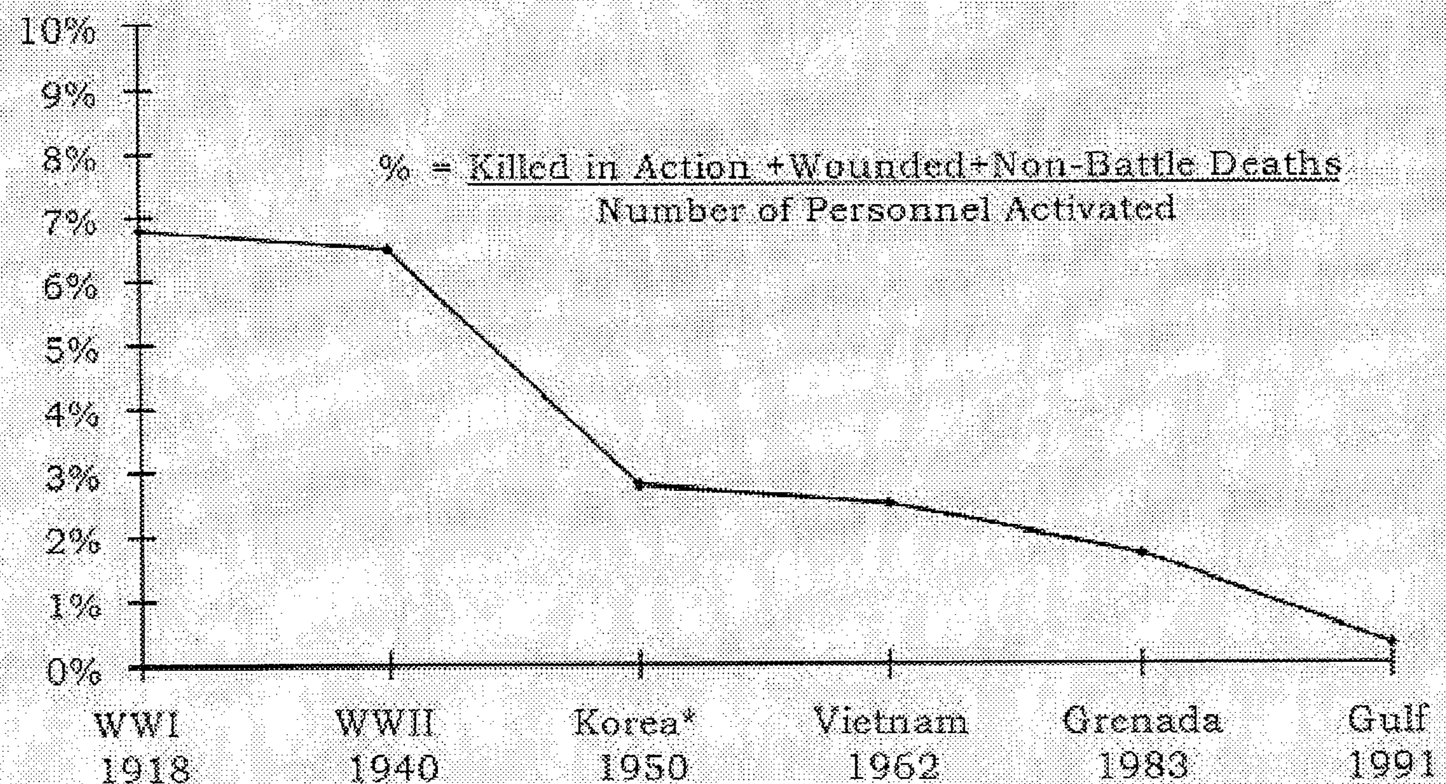
Battlespace Dominance

Force Sustainment

Power Projection



COMBAT CASUALTIES



Source: Army History Office

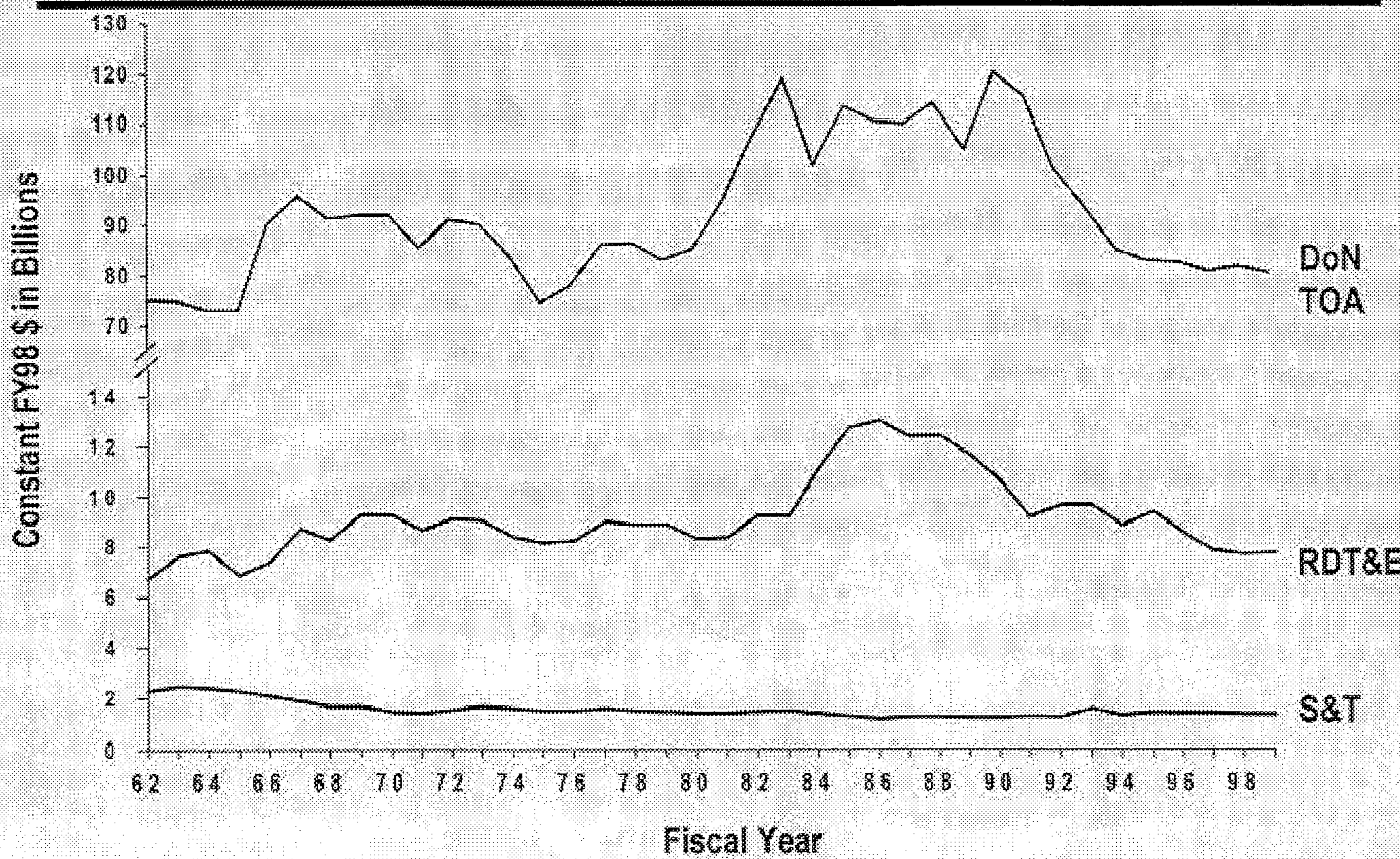
* Non-Battle Deaths Estimated

S&T ENVIRONMENT

- LEVEL OR REDUCED BUDGETS
- INCREASED JOINTNESS
- GREATER ACCEPTANCE OF COTS (MATURE TECHNOLOGY)
- INDUSTRIAL TEAMING INCREASING; <u>BUT</u> ....
  - BASIC RESEARCH DECLINE
  - DISMANTLED CENTRAL RESEARCH FACILITIES
  - RAPID COMMERCIALIZATION OF NEW TECHNOLOGY

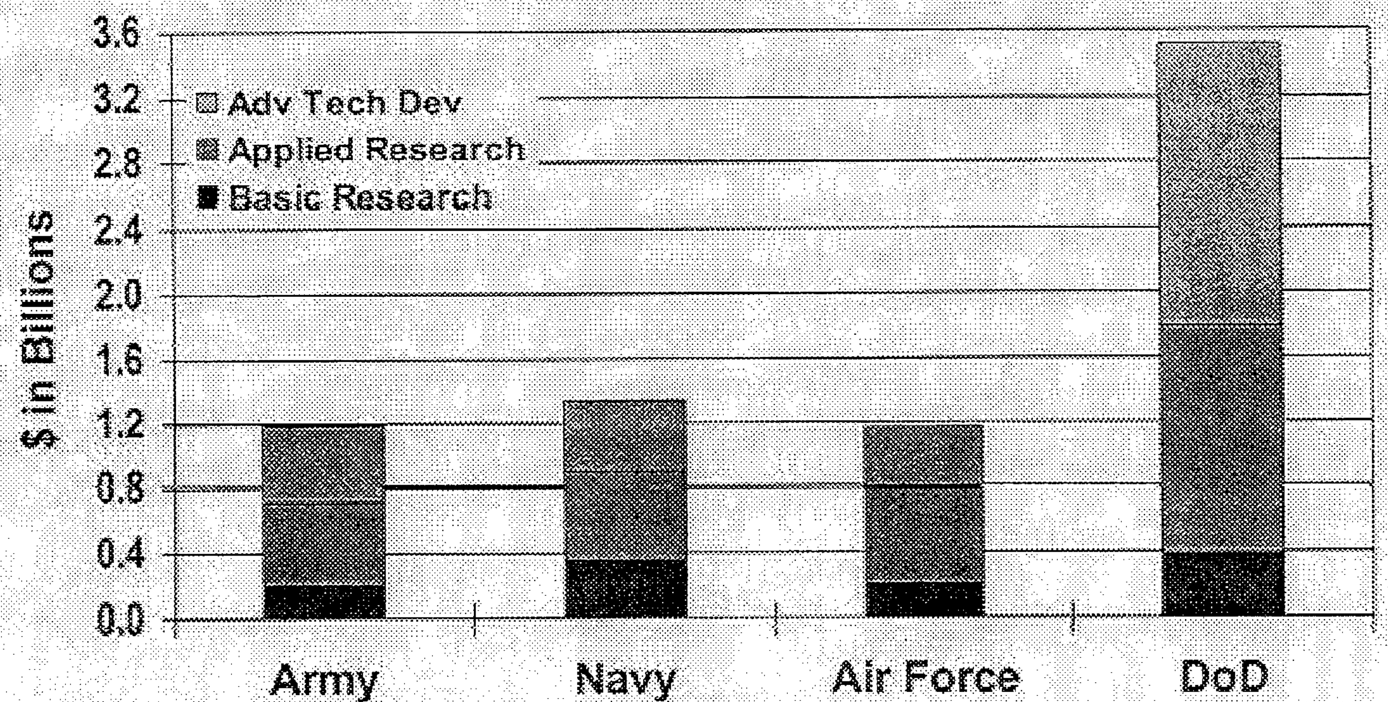
source: National Science Board, *Science & Engineering Indicators 1996*, Washington DC: US Government Printing Office, 1996 (NSB96-21), p. 4-10.

HISTORY OF DoN TOA, RDT&E AND S&T



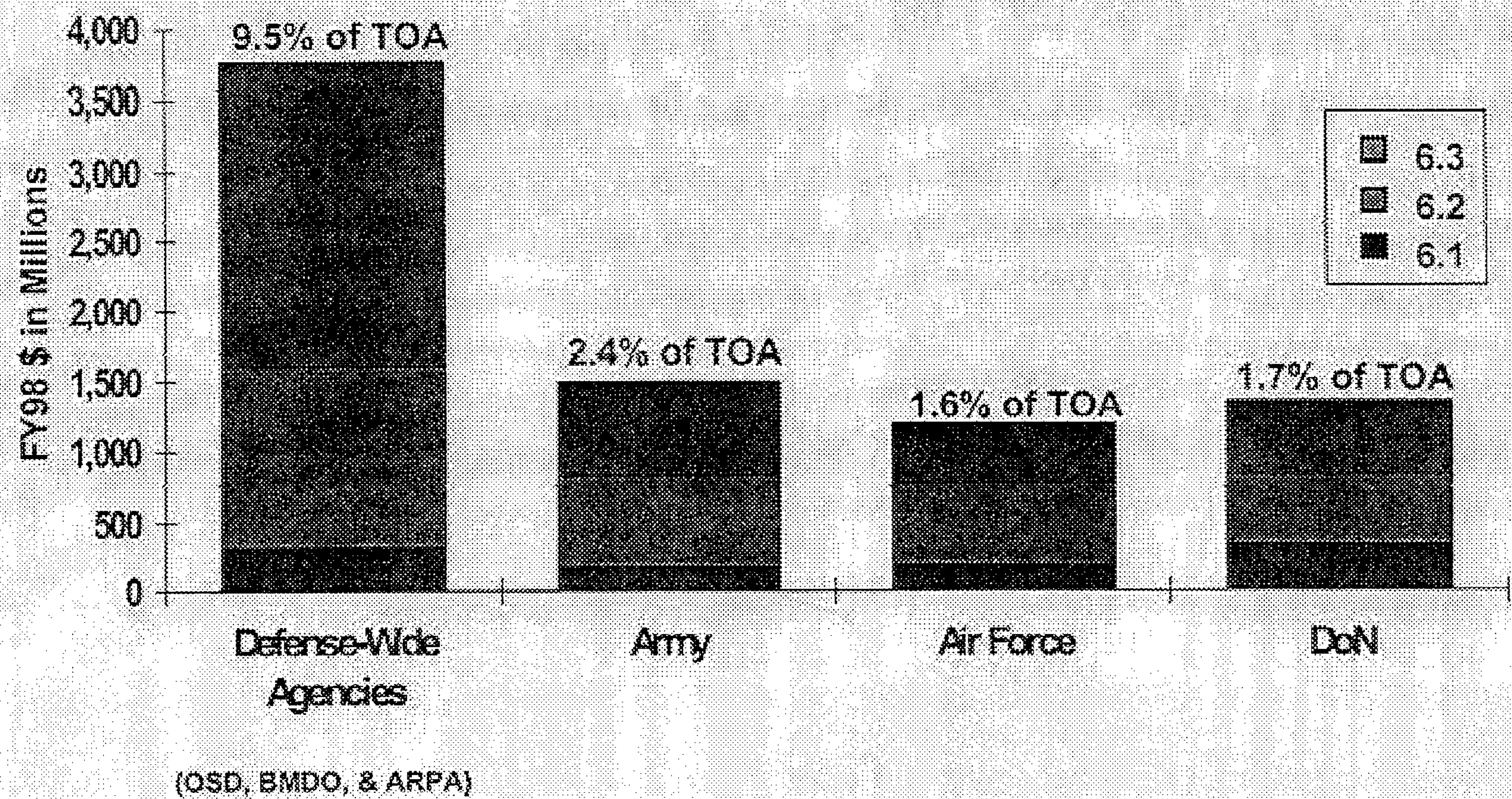
FY99 PRESIDENT'S BUDGET REQUEST FOR DoD S&T

Total FY99 S&T = $7.2B

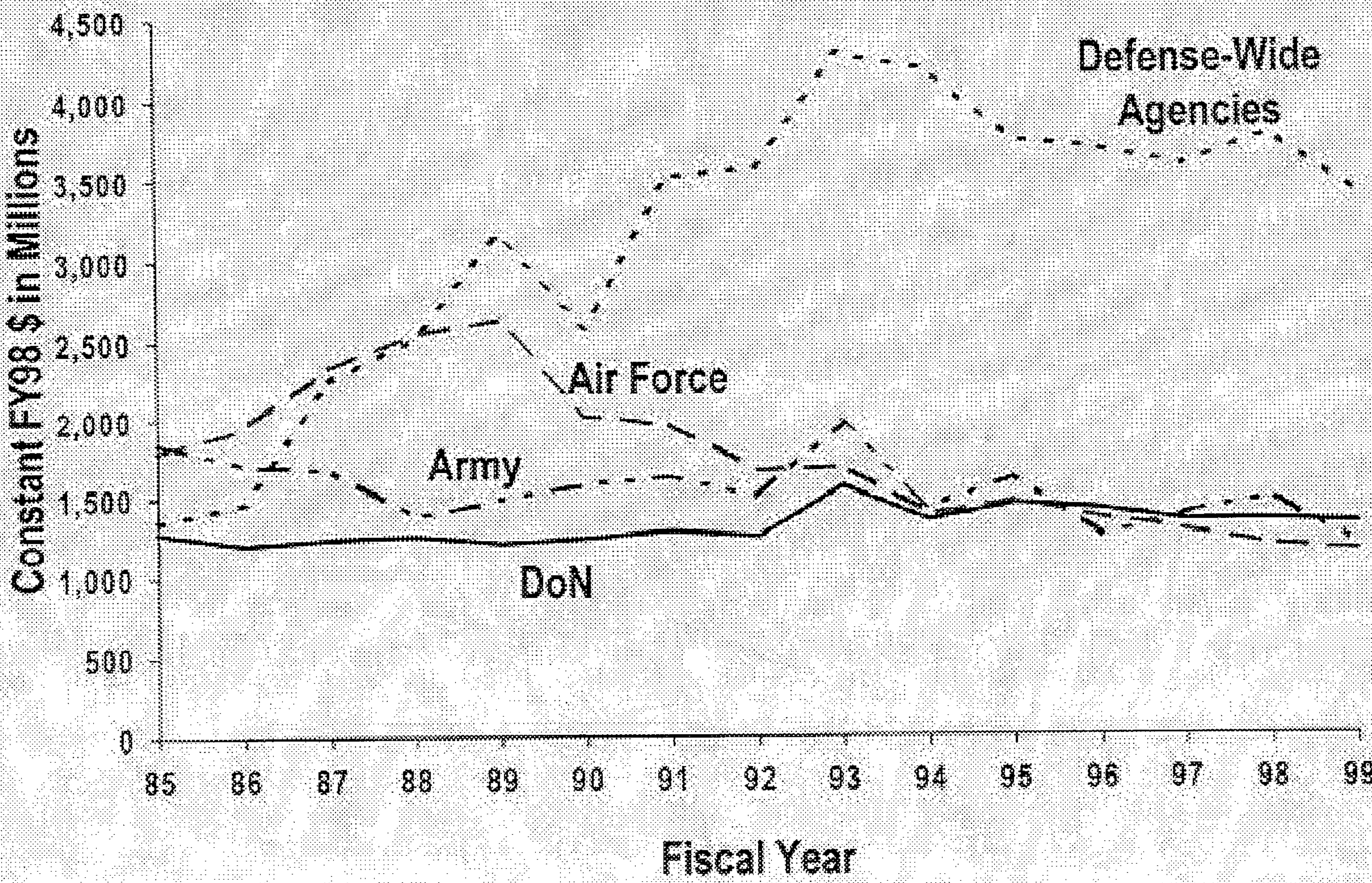


Source: DDR&E

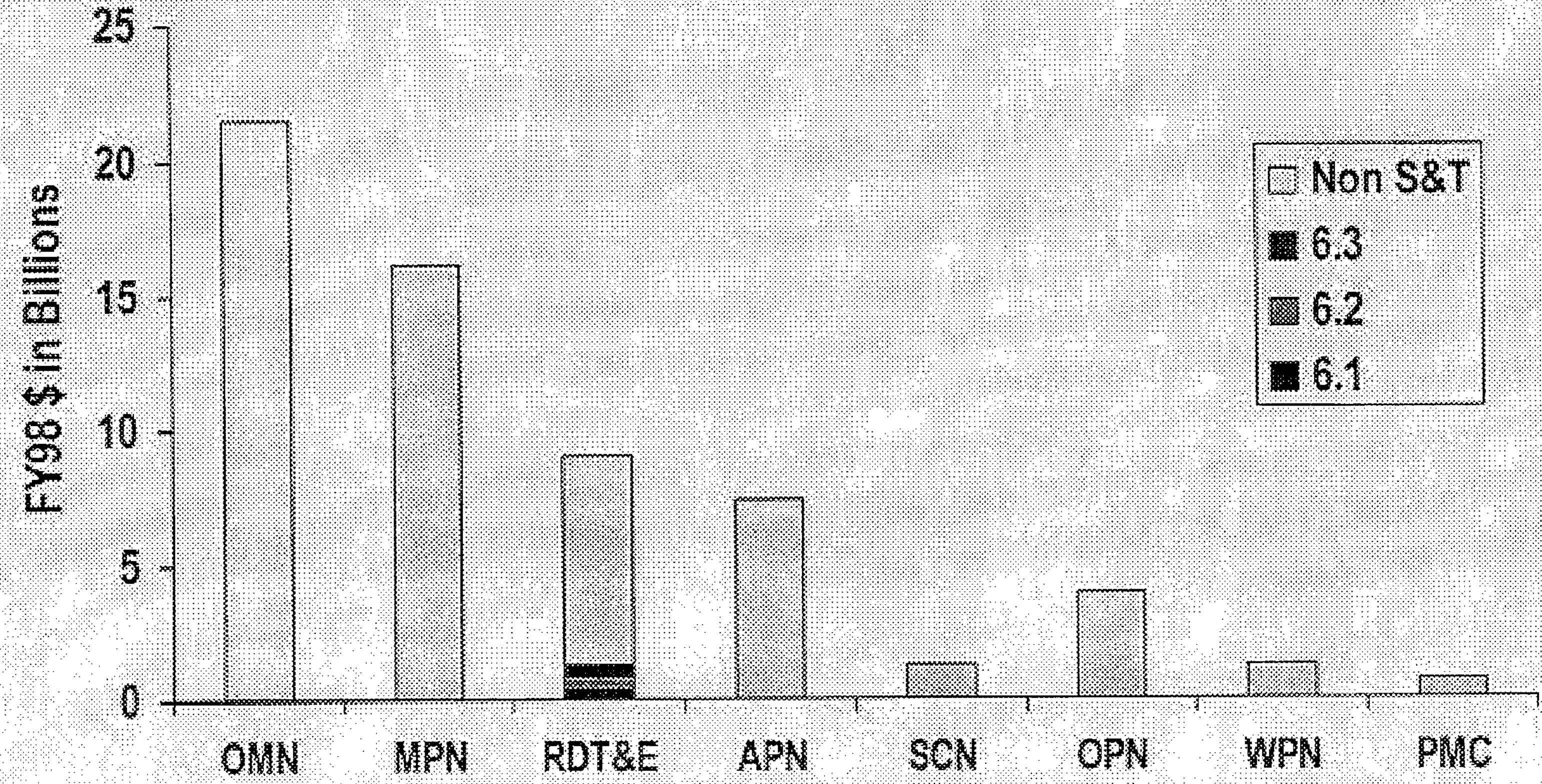
DoD S&T FY98 INVESTMENT



COMPARISON OF DoD S&T ACCOUNTS



DoN FY99 PRESIDENT'S BUDGET



S&T PROGRAMMING TRENDS

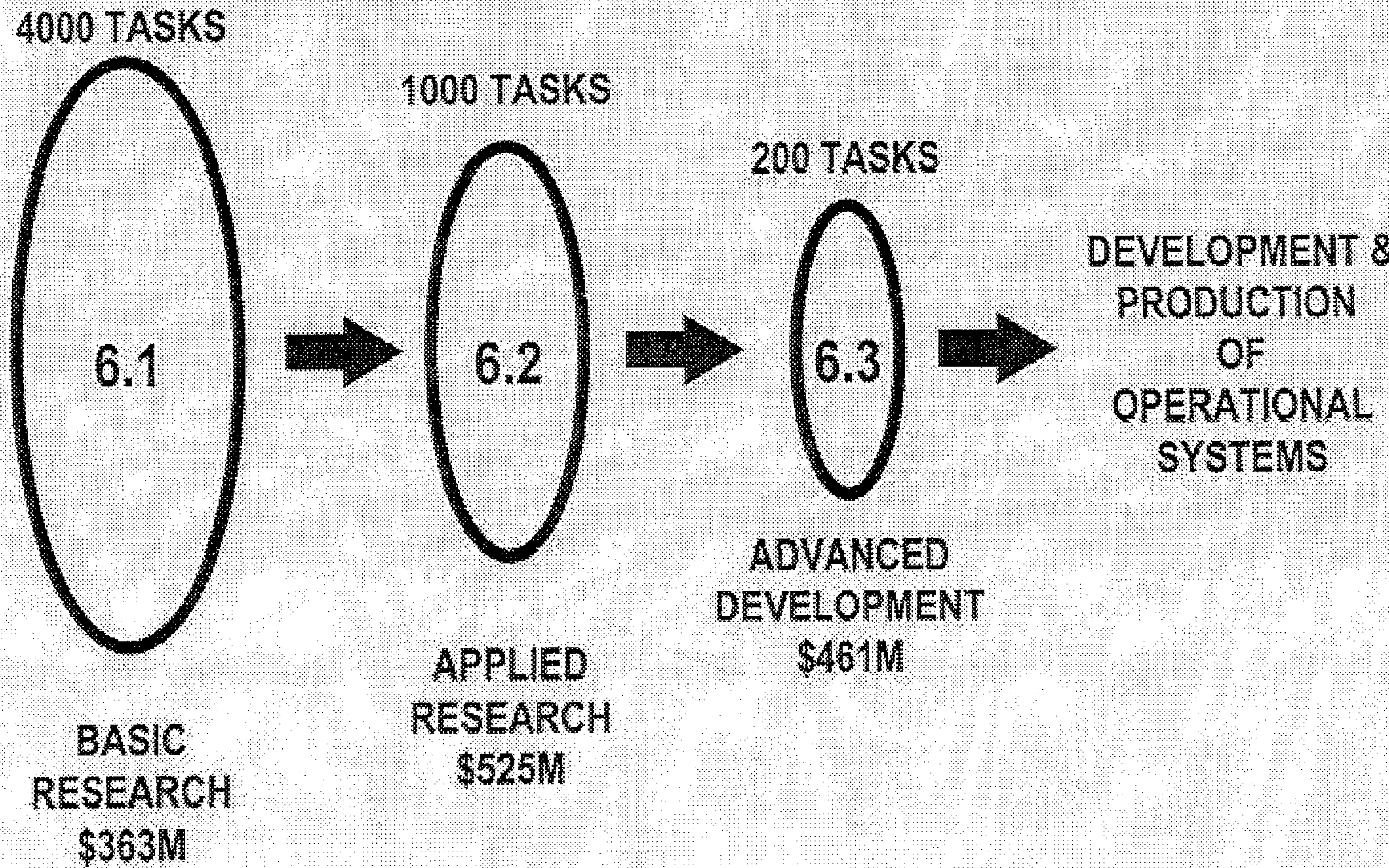
INCREASED EMPHASIS

- EXTENDING THE LITTORAL BATTLESPACE
- NETWORK CENTRIC WARFARE
- REDUCED MANNING
- AFFORDABILITY
- DD-21

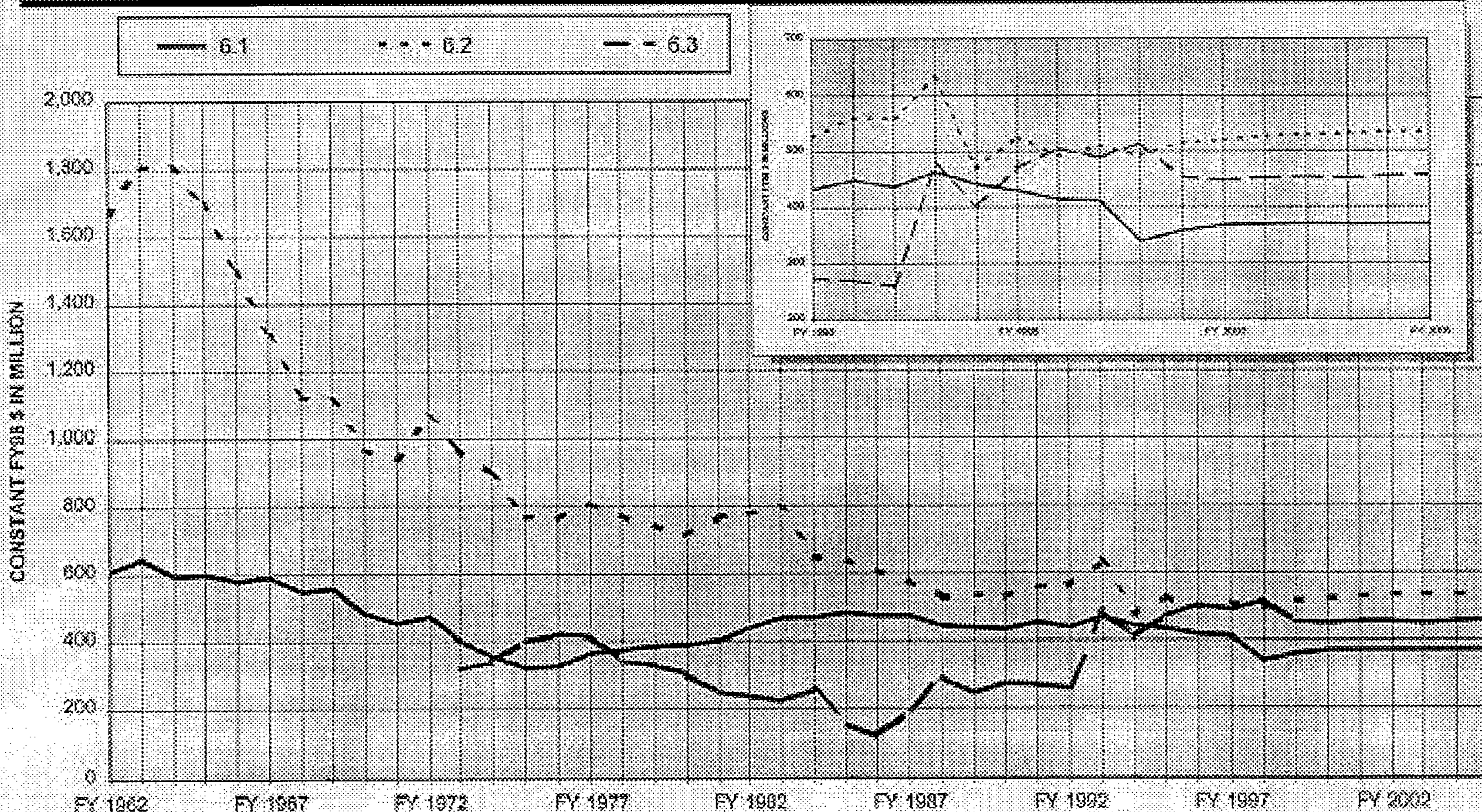
DECREASED EMPHASIS

- OPEN OCEAN/ARTIC ASW
- ANTI-SURFACE WARFARE
- ELECTRIC DRIVE

DoN S&T PROGRAM RELATIONS

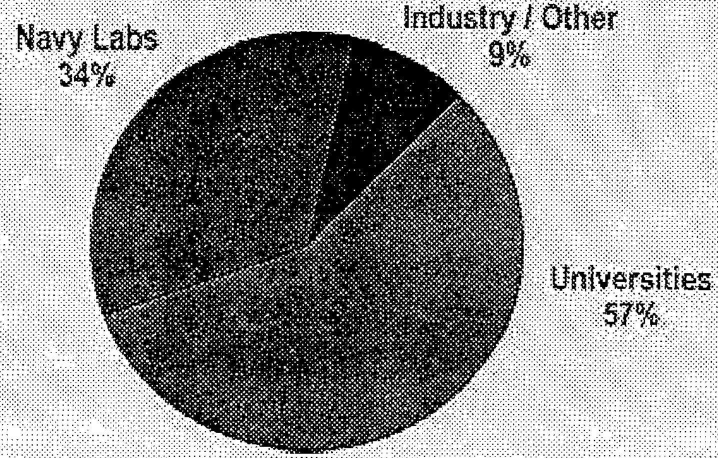


DoN S&T PROGRAM HISTORY



* FY00 - FY05 do not reflect SPP

DoN S&T FY98 BREAKDOWN



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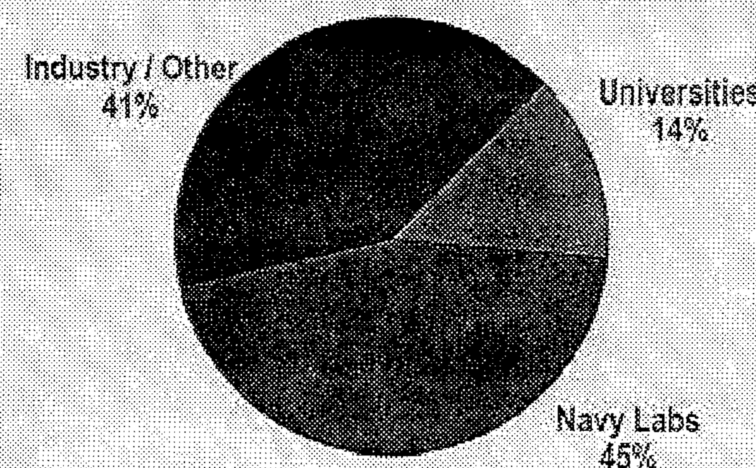

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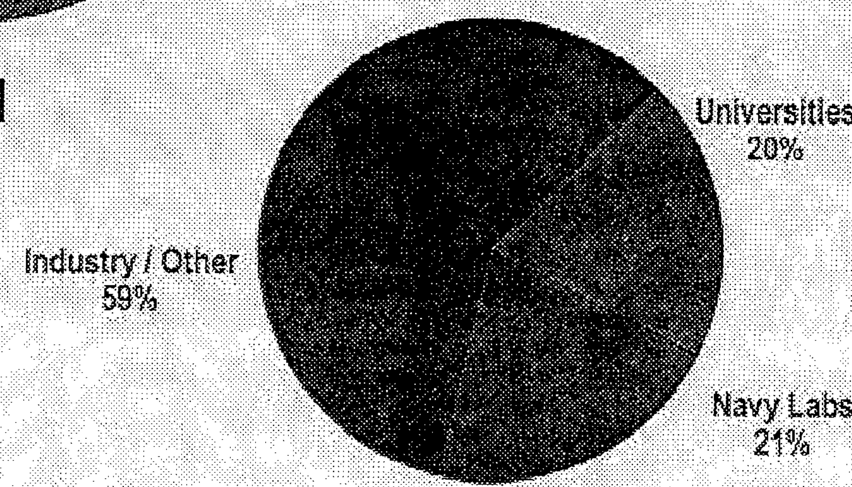
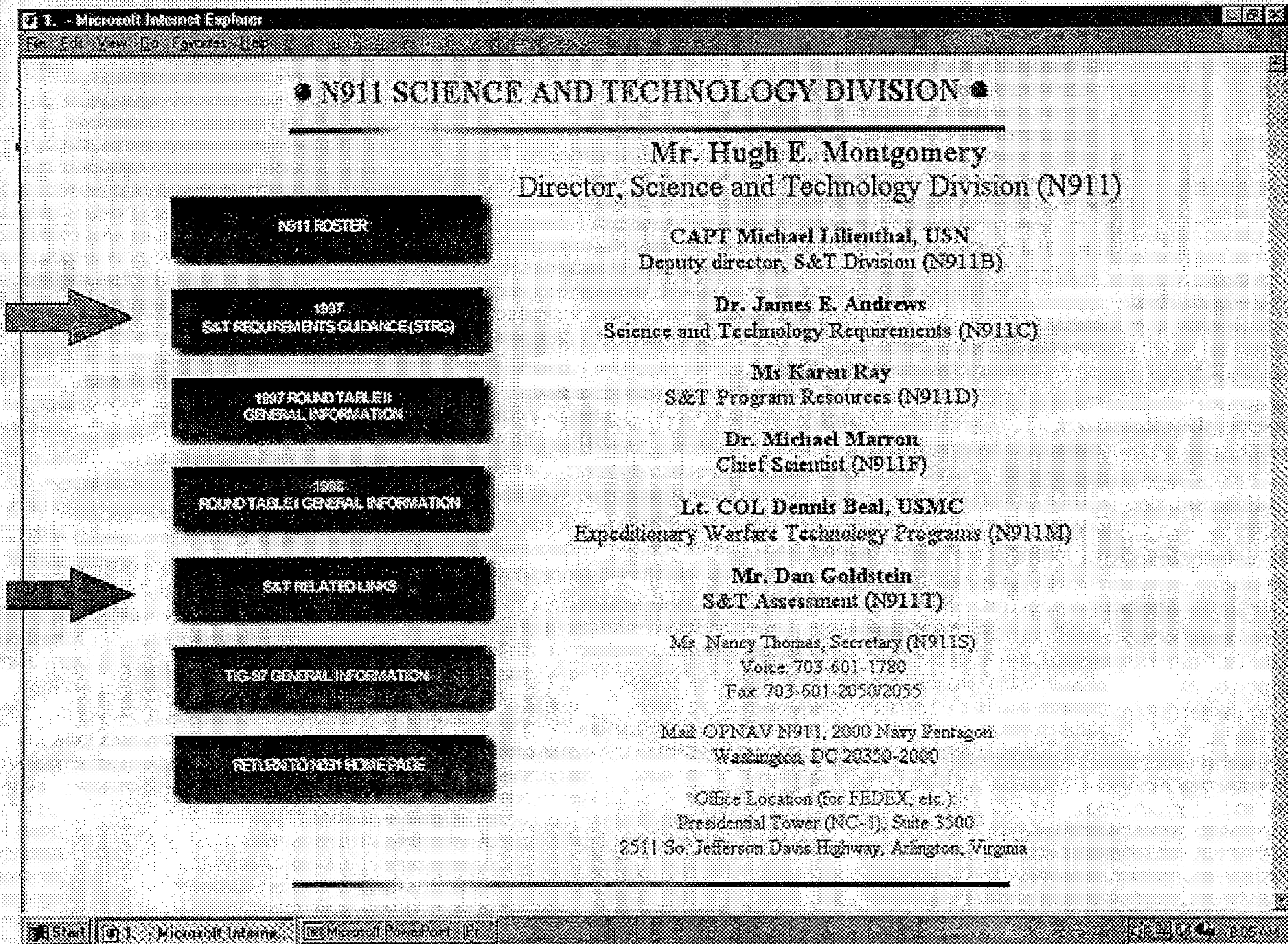


6.3


N091 HOME PAGE - Microsoft Internet Explorer
•WELCOME TO N091•
Our Missions and Functions
N091B
Assistant for Programming and Budget
N911
Science and Technology Division
N912
Test and Evaluation Division
N913
T&E Resource & Infrastructure Division
Senior National Representatives (SNR)
UNITED STATES NAVY
CHIEF OF NAVAL OPERATIONS
Meet the Director
Meet the Deputy Director
Office of the Chief of Naval Operations
Director, Test and Evaluation and
Technology Requirements (N091)
• WARNING NOTICE•
http://www.hq.navy.mil/n091
Start
N091 HOME PAGE

043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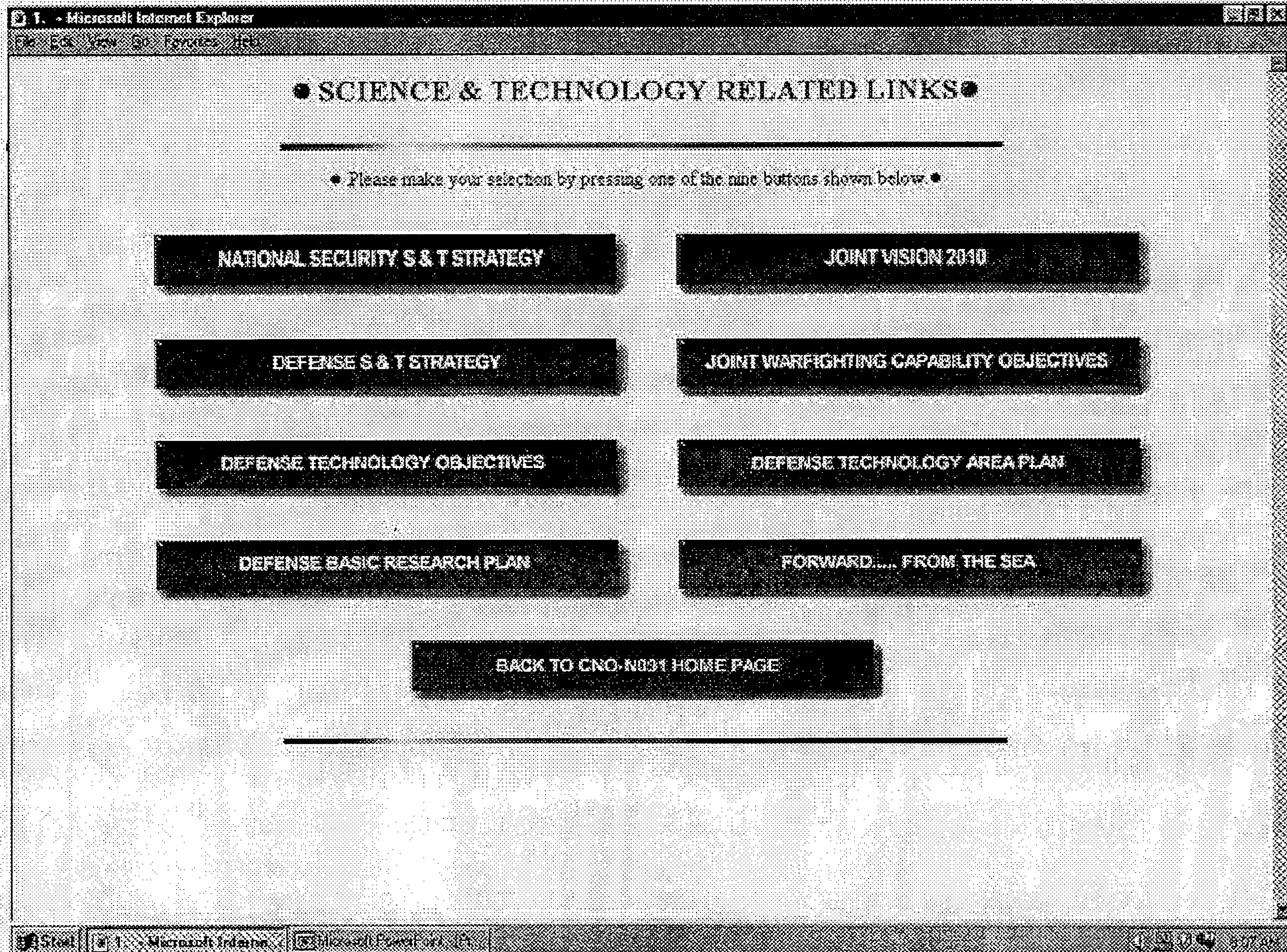
● N911 SCIENCE AND TECHNOLOGY DIVISION ●
Mr. Hugh E. Montgomery
Director, Science and Technology Division (N911)
N911 ROSTER
1997
S&T REQUIREMENTS GUIDANCE (STRG)
1997 ROUND TABLE II
GENERAL INFORMATION
1998
ROUND TABLE I GENERAL INFORMATION
S&T RELATED LINKS
TIG-97 GENERAL INFORMATION
RETURN TO N911 HOME PAGE
CAPT Michael Lilienthal, USN
Deputy director, S&T Division (N911B)
Dr. James E. Andrews
Science and Technology Requirements (N911C)
Ms Karen Ray
S&T Program Resources (N911D)
Dr. Michael Marron
Chief Scientist (N911F)
Lt. COL Dennis Beal, USMC
Expeditionary Warfare Technology Programs (N911M)
Mr. Dan Goldstein
S&T Assessment (N911T)
Ms Nancy Thomas, Secretary (N911S)
Voice: 703-601-1780
Fax 703-601-2050/2055
Mail OPNAV N911, 2000 Navy Pentagon
Washington, DC 20350-2000
Office Location (for FEDEX, etc.):
Presidential Tower (NC-1), Suite 3300
2511 So. Jefferson Davis Highway, Arlington, Virginia
Start
Microsoft PowerPoint


1. - Microsoft Internet Explorer
File Edit View Go Favorites Help
● SCIENCE & TECHNOLOGY RELATED LINKS ●
● Please make your selection by pressing one of the nine buttons shown below ●
NATIONAL SECURITY S & T STRATEGY
JOINT VISION 2010
DEFENSE S & T STRATEGY
JOINT WARFIGHTING CAPABILITY OBJECTIVES
DEFENSE TECHNOLOGY OBJECTIVES
DEFENSE TECHNOLOGY AREA PLAN
DEFENSE BASIC RESEARCH PLAN
FORWARD..... FROM THE SEA
BACK TO CNO-N031 HOME PAGE
Start

945

NAVY ADVANCED TECHNOLOGY DEMONSTRATIONS (ATDs)

- NAVY CREATED ATDs IN FY87
- TRANSITION OF HIGHEST PAYOFF TECHNOLOGIES
- RISK REDUCTION
- REQUIREMENTS DRIVEN
- FINITE DURATION
- TRANSITION PLAN
- RIGOROUS SELECTION AND REVIEW PROCESS

ADVANCED CONCEPT TECHNOLOGY DEMONSTRATIONS

- NEXT STEP BEYOND ATDs
- TRANSITION LOWER RISK JOINT TECHNOLOGIES
- FIELDABLE PROTOTYPE LEGACY
- SERVICE FUNDING

FY99 ISSUES

- S&T INVESTMENT
  - S&T DID NOT SHARE IN THE REAGAN BUILDUP; HEAVY PRESSURE TO DECREASE
  - 6.1 REDUCED BY CONGRESS IN FY98
  - 6.2 IN 30 YEAR DECLINE
- CONGRESSIONAL ISSUES
  - S&T PROGRAM STABILITY
  - BALANCED BUDGET IMPACTS
  - CONGRESSIONAL REBALANCING OF PROGRAM
  - ATD FUNDING LEVEL
  - VECTOR
- OUTSOURCING
  - INCREASING INDUSTRY SHARE OF S&T
  - MINIMAL IR&D PROGRAM VISIBLITY
  - ROLE OF IN-HOUSE R&D FACILITIES

S&T BOTTOM LINE

- LOW THREAT ALLOWS INCREASED FOCUS ON S&T (5-20 YEAR HORIZON)
- LOW INDUSTRY / ACADEMIA S&T INVESTMENT
- DoD S&T INVESTMENT DOWN, ESPECIALLY IN 6.3
- TWO MANAGEMENT CHOICES:
  - INCREASE FUNDING
  - INCREASE FOCUS

JOINT SERVICES AVIONICS (JSA)

ARMY TECHNOLOGY THRUSTS

BRIEFING TO INDUSTRY   17 JUNE 1998

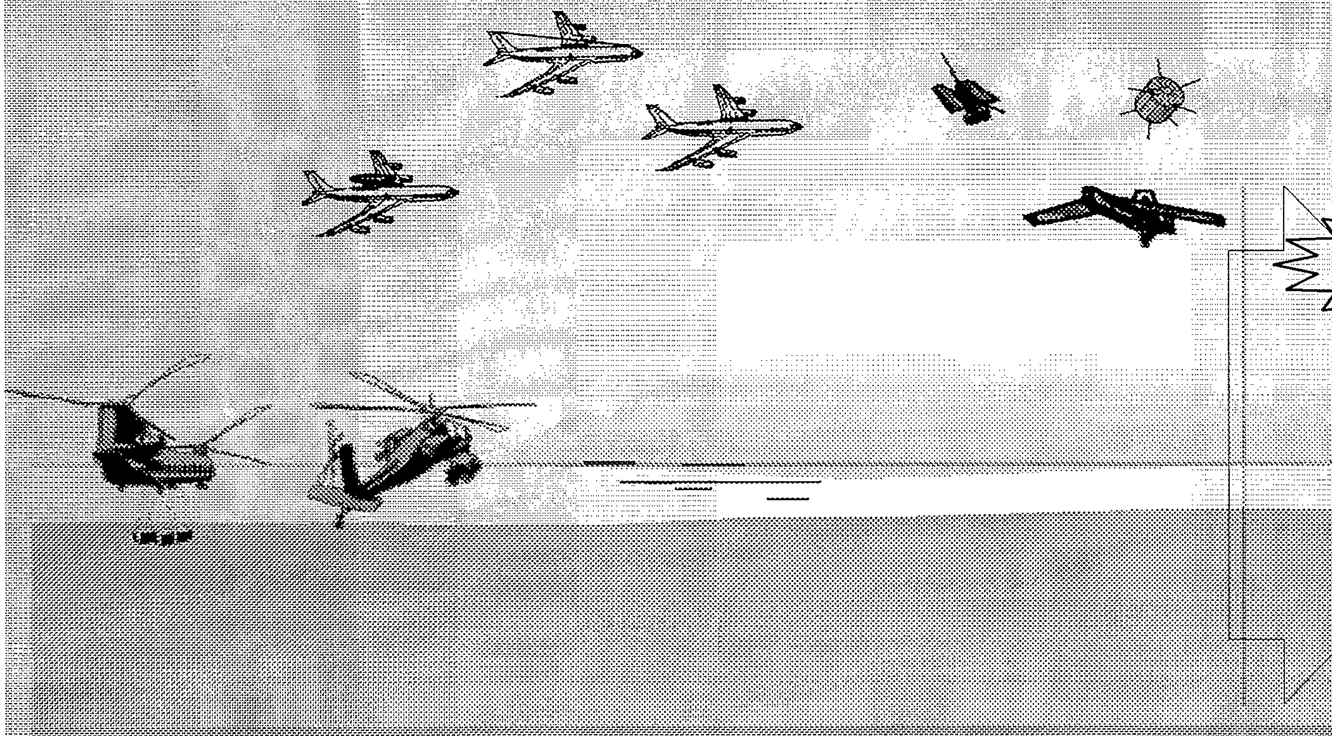
JOHN MACRINO
Chief, Mission Equipment Integration Division
AVRDEC-AATD
AMCOM
757-878-2122

CRIS TSOUBANOS
Chief, Technical Integration Division
AVRDEC-DAS
AMCOM
256-313-2399

P-TI-169-98

950

Aviation Vision



Lethal

Joint
Precision
Response

Non-Lethal

LAND FORCE DOMINANCE

A Relevant Force for the Future

Versatile
Flexible
Modular
Deployable
Sustainable

ARMY TECHNOLOGY THRUSTS
AGENDA

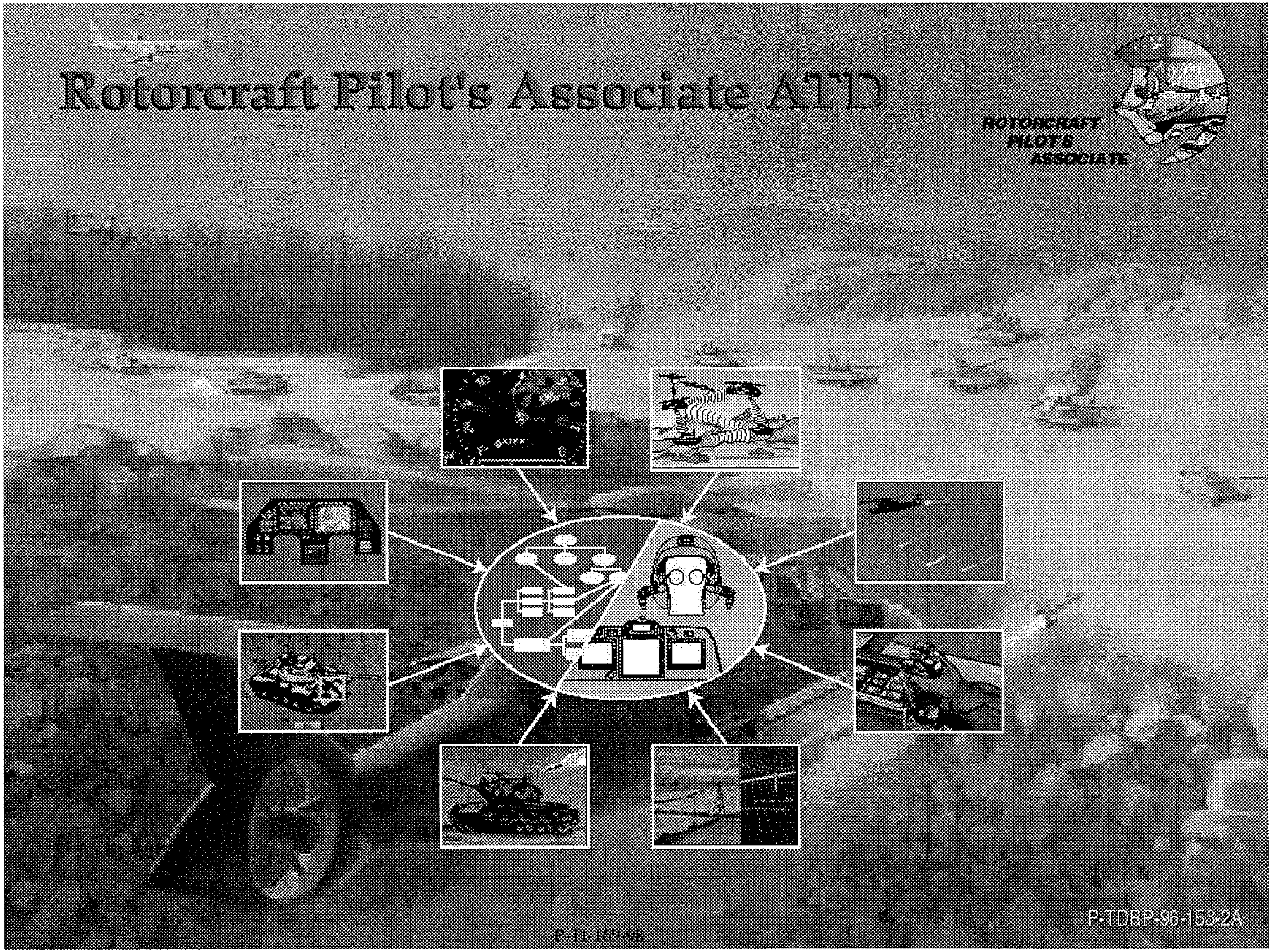
CURRENT PROGRAMS

Rotorcraft Pilots Associate (RPA)

Airborne Manned/Unmanned System Tech Demo (AMUST)

PLANNED PROGRAM

Helicopter Integrated Low-cost Avionics Demo (HILAD)


Rotorcraft Pilot's Associate ATD
ROTORCRAFT
PILOT'S
ASSOCIATE
P-TDRP-96-153-2A

RPA FUNCTIONAL OVERVIEW

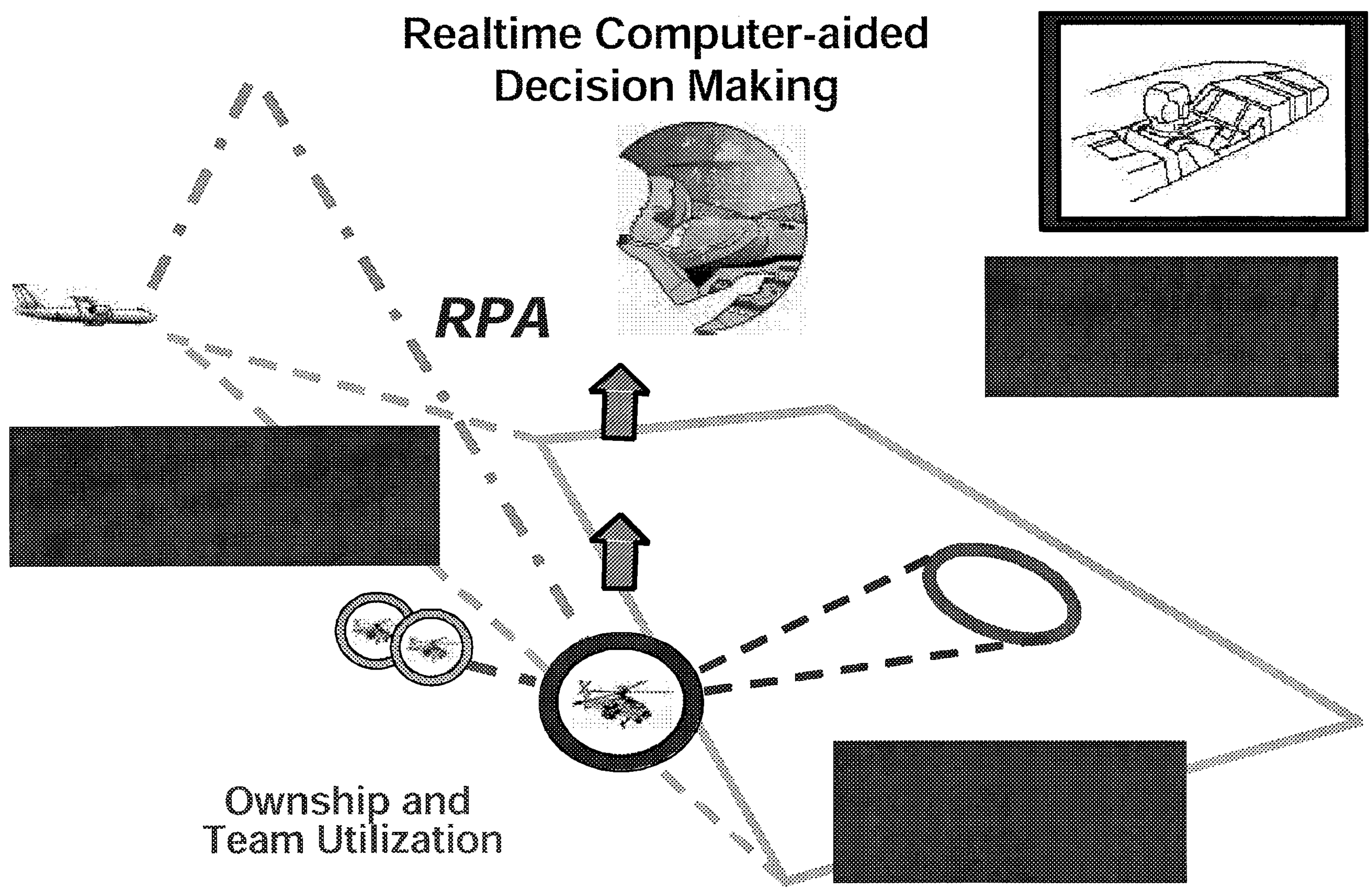
ROTORCRAFT PILOT'S ASSOCIATE

Knowledge based *ASSOCIATE* system for cognitive decision aiding

An application of artificial intelligence, advanced computing techniques, and next generation controls and displays which will provide real time:

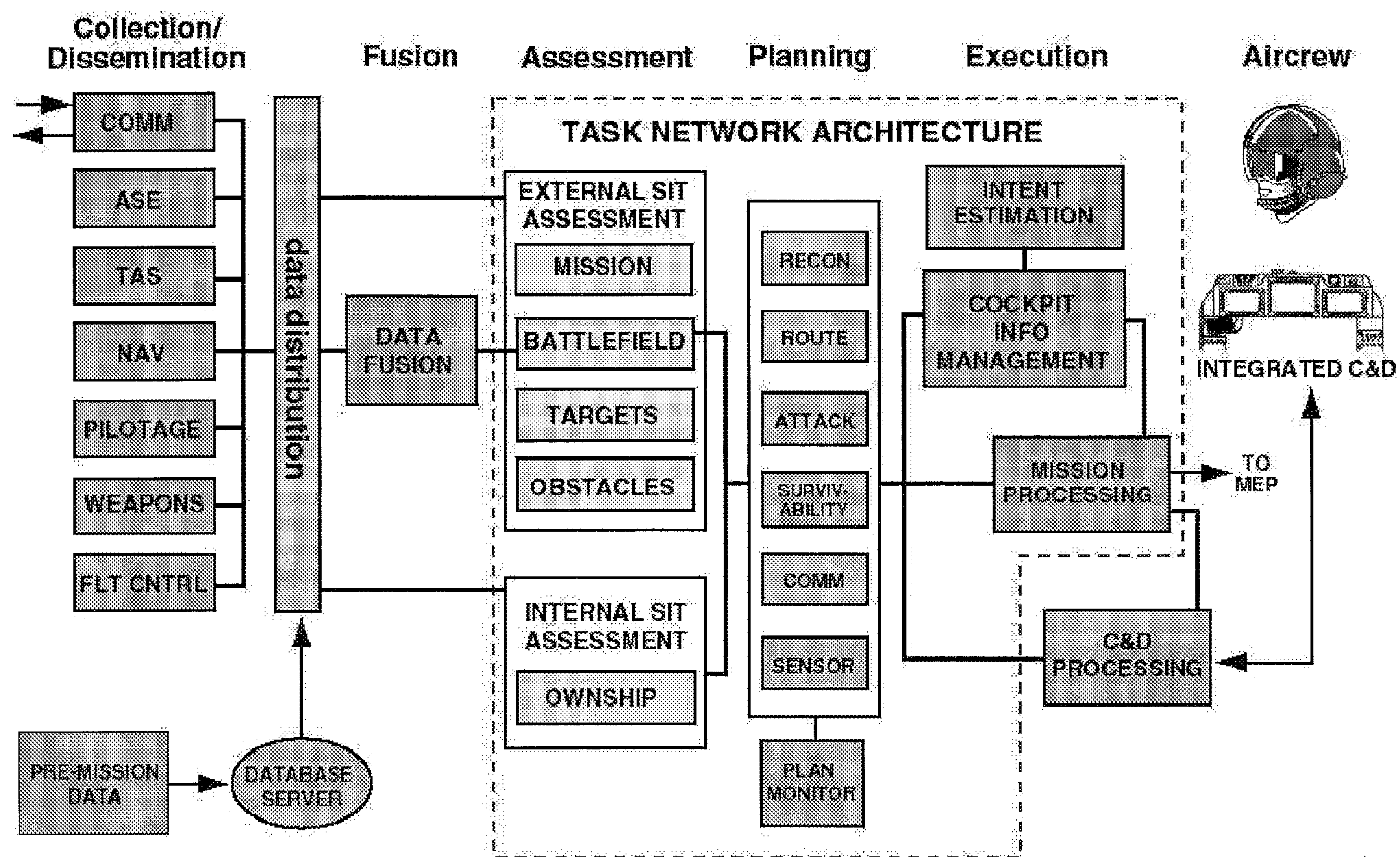
- Automated continuous mission planning (routes, battle positions, observation points, etc.)
- Comprehensive utilization of digital battlefield information
- Automated, context sensitive reconfiguration/control of mission equipment
- Efficient and intuitive cockpit information management
- Greatly improved situation awareness
- Synchronization of team operations and management of assets

P-TI-169-98


Realtime Computer-aided
Decision Making
RPA
Ownship and
Team Utilization

P-TI-169-98

MISSION MANAGEMENT



P-TI-169-98

PROGRAM GOALS

ROTORCRAFT PILOT'S ASSOCIATE

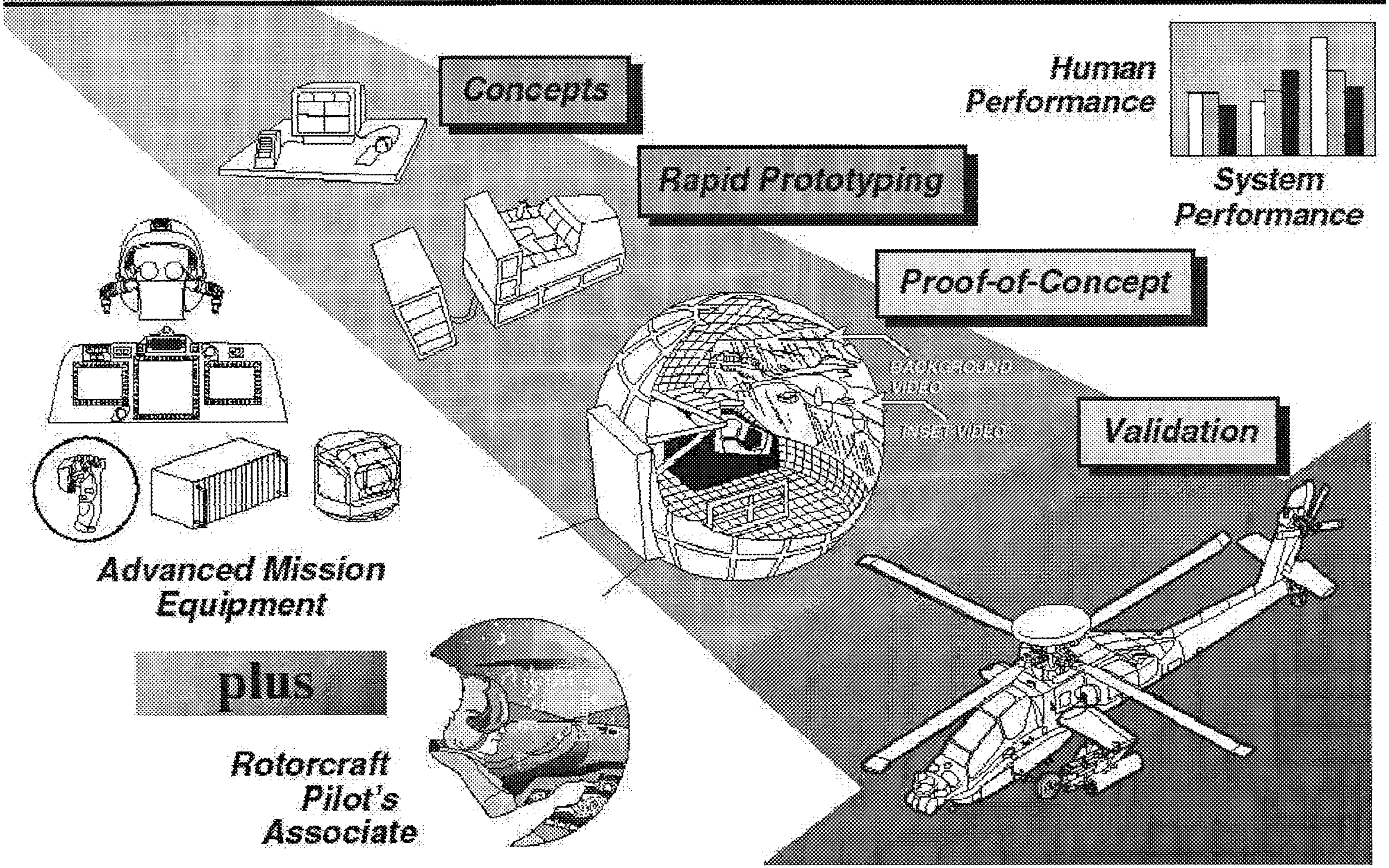
MEASURES OF EFFECTIVENESS (MOE'S)

CHARACTERISTICS	EXIT CRITERIA	GOAL
Reduction in mission losses	30%	60%
Increased targets destroyed	50%	150%
Reduced mission timelines	20%	30%

(Comanche-Like MEP Baseline)

P-TI-169-98

RPA EVALUATIONS



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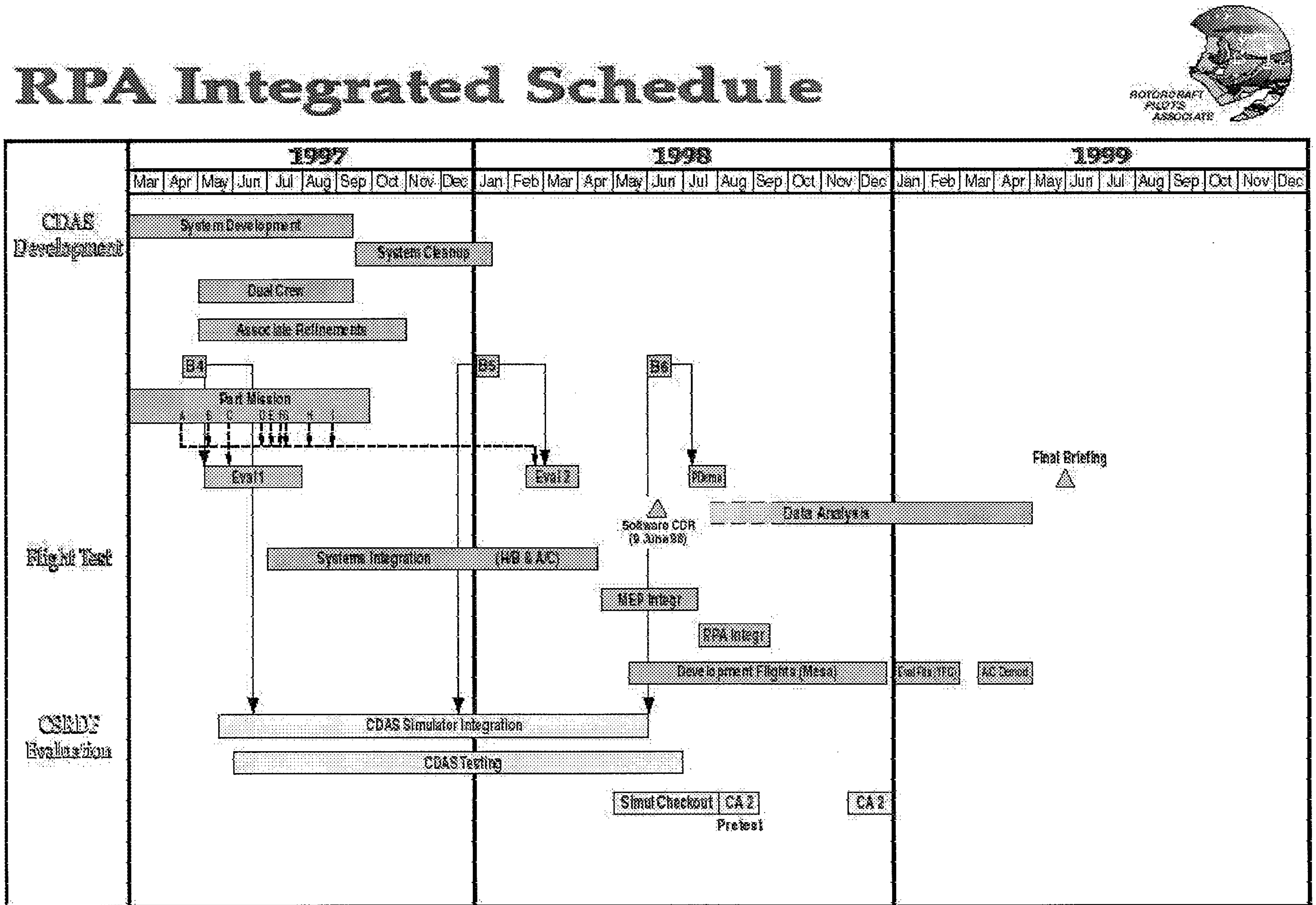
RPA Integrated Schedule



3/13/98

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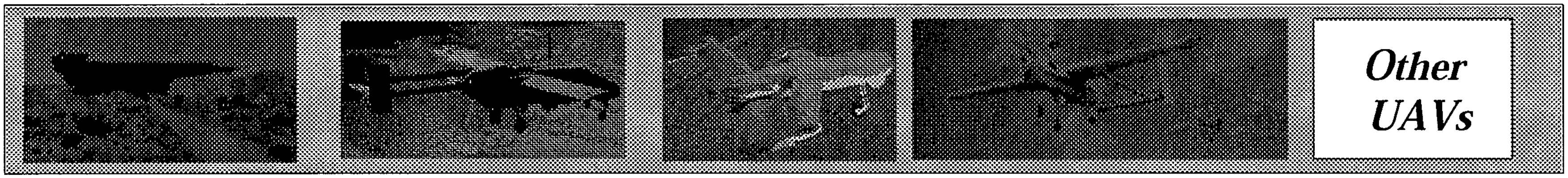
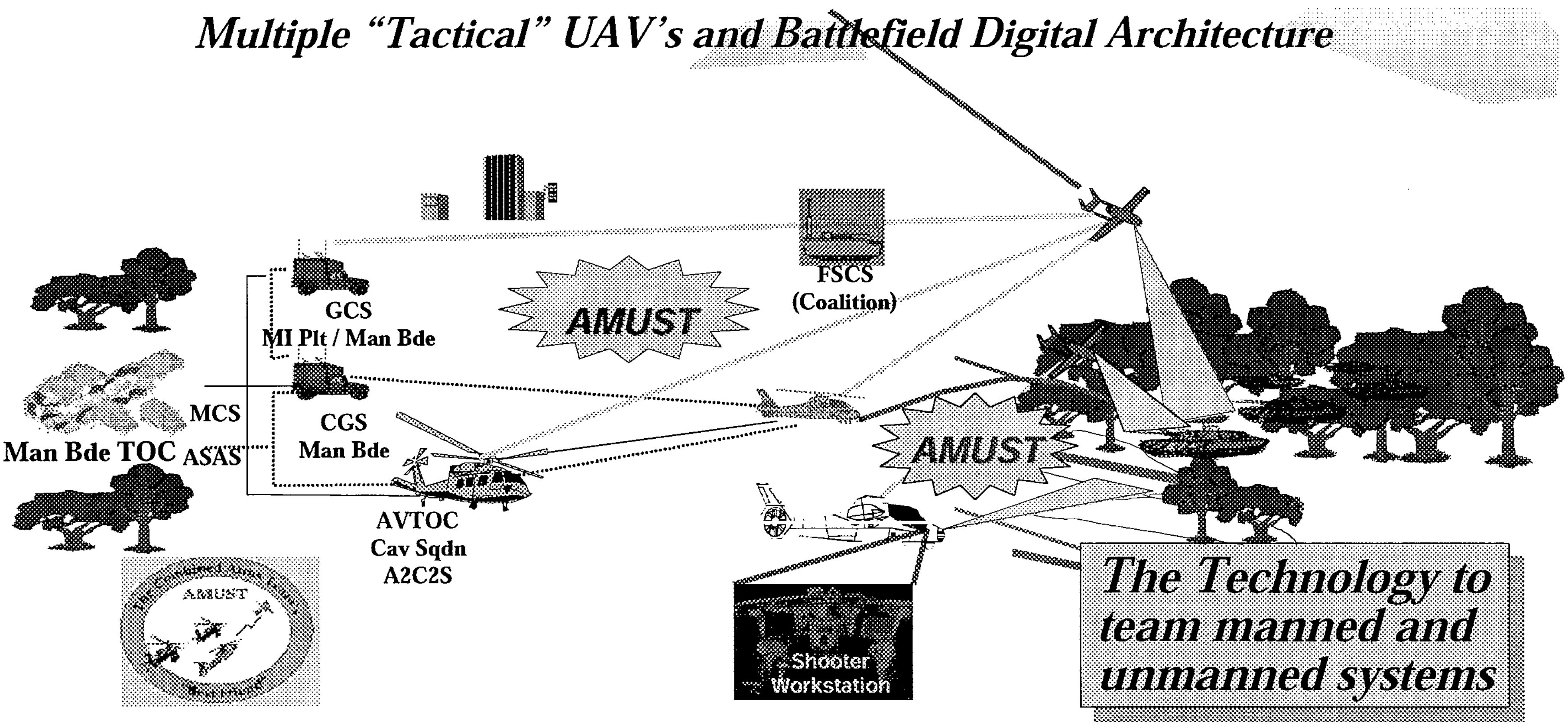
Airborne Manned/Unmanned System Technology (AMUST)



Multiple "Tactical" UAV's and Battlefield Digital Architecture



P-TI-169-98

AMUST-D
Technical Objective

Demonstrate through simulation and flight tests the control mechanisms, intelligent linkages and integration architectures to allow Manned Air Vehicle/Unmanned Air Vehicle (MAV/UAV) system to operate as an effective warfighting system of systems to increase the combined arms team battlefield effectiveness

AMUST-D
Pay-offs

What are you getting for your money

- Improved operational effectiveness
- Increased operational efficiency
- Increased survivability
- Improved target acquisition
- Improved situational awareness
- Increased mission flexibility
- Maximize use of weapons stand-off range
- Real-time Battle Damage Assessment (BDA)
- Frequency Spectrum Management
- and more...

AMUST-D

Leveraged Technologies

CECOM Sensors
>Multi-Mission Common Modular UAV Sensor
>Advanced sensor efforts

CECOM Communication
>Non-line-of-sight communications
>High band width communication efforts

AMUST 6.2 STO
>Trade-off Study
>Sensor & Vehicle Evaluation
>Real time information assessment
>Functionality Assessment

TRADOC CEP
>Effectiveness
>Operational Evaluation
>TTPs
>Control Relationships

AMCOM RPA
>Cognitive Decision Aiding
>Mission Planning
>Data Fusion

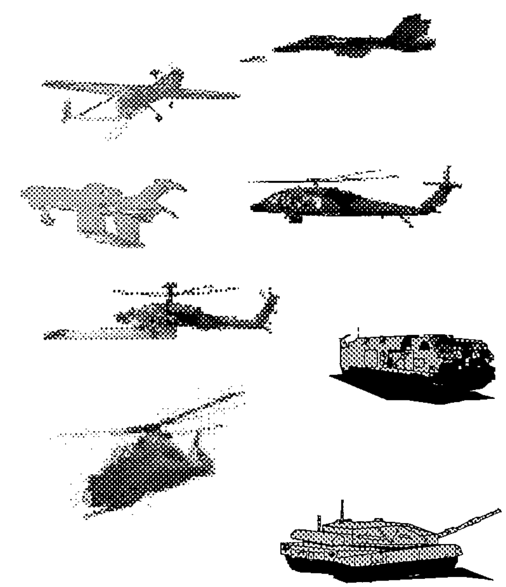
UAV JPO
>Outrider
>Hunter
>Tactical Control Station
>Sensor & Vehicle

AMUST-D

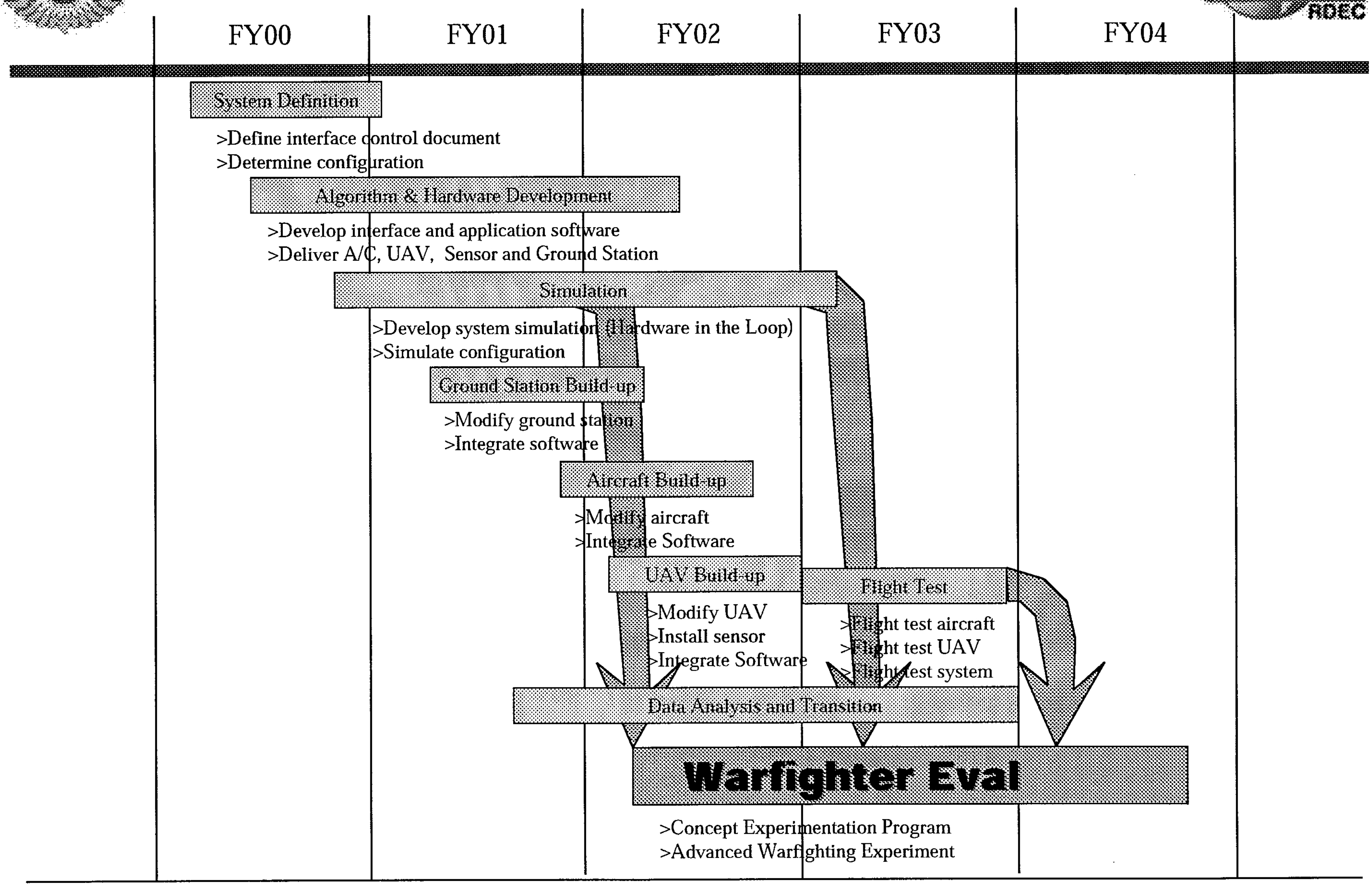
>System Definition
>Algorithm & Hardware Development
>Simulation
>Ground Station Build-up
>Aircraft Build-up
>UAV Build-up
>Flight Test
>Data Analysis and Transition

Warfighter Eval
>Concept Experimentation Program
>Advanced Warfighting Experiment

PEO/PM Upgrades



AMUST-D


FY00
FY01
FY02
FY03
FY04
System Definition
>Define interface control document
>Determine configuration
Algorithm & Hardware Development
>Develop interface and application software
>Deliver A/C, UAV, Sensor and Ground Station
Simulation
>Develop system simulation (Hardware in the Loop)
>Simulate configuration
Ground Station Build-up
>Modify ground station
>Integrate software
Aircraft Build-up
>Modify aircraft
>Integrate Software
UAV Build-up
>Modify UAV
>Install sensor
>Integrate Software
Flight Test
>Flight test aircraft
>Flight test UAV
>Flight test system
Data Analysis and Transition
Warfighter Eval
>Concept Experimentation Program
>Advanced Warfighting Experiment

ARMY TECHNOLOGY THRUSTS
R&D VIEW TODAY
Avionics Architecture

- DUAL 1553 B VIDEO AND HIGH SPEED BUSES

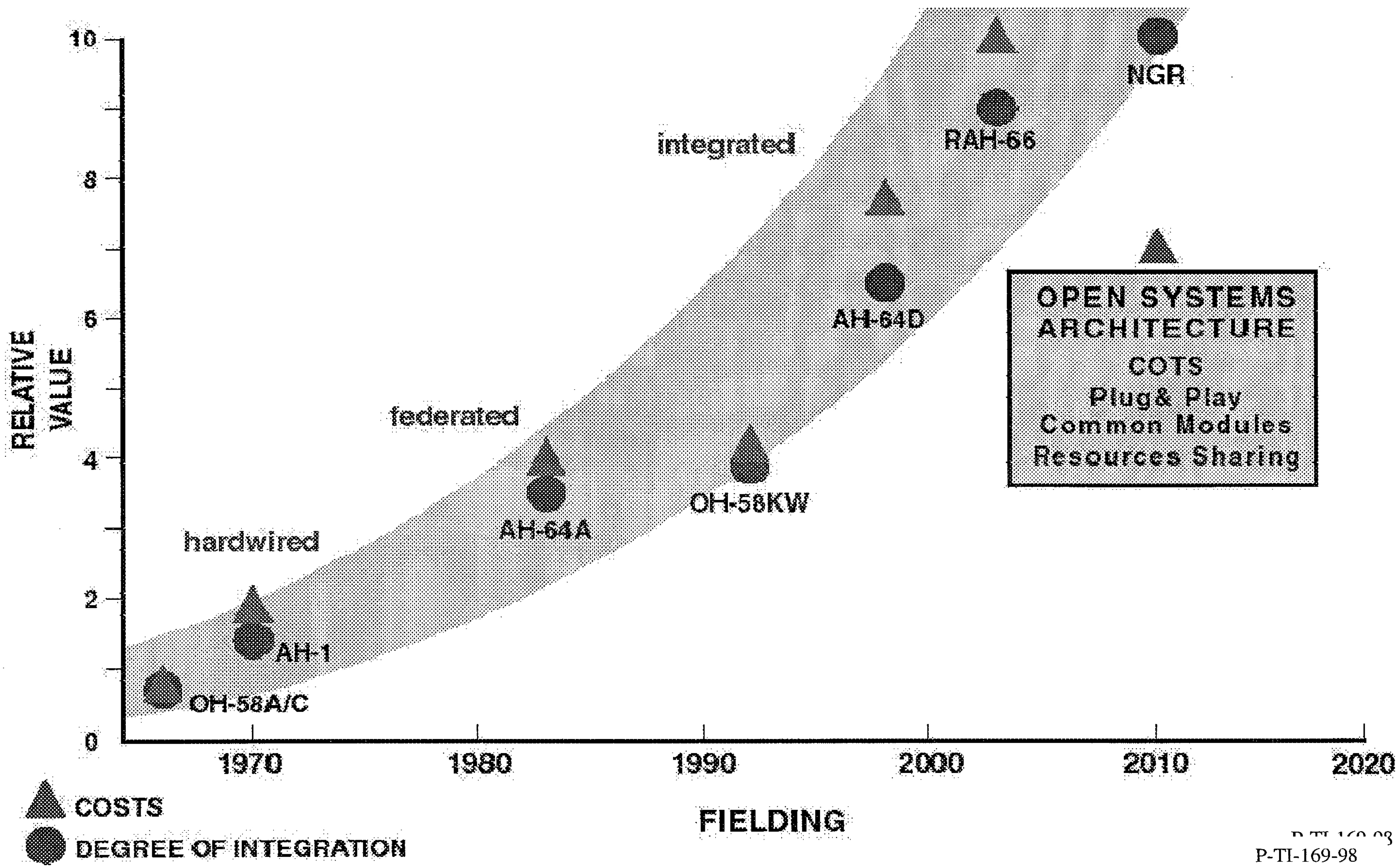
JIAWG(-) ICNIA(-)

FEDERATED (+)

- OSD MANDATED OPEN SYSTEMS ARCHITECTURE
  - JOINT TECHNICAL ARCHITECTURE – JTA
  - JTA-A

Affordability – Major Issue

ARMY TECHNOLOGY THRUSTS
HELICOPTER AVIONICS INTEGRATION
Scout/Attack



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6

ARMY TECHNOLOGY THRUSTS
S&T STRATEGY

MISSION EQUIPMENT TECHNOLOGY DEVELOPMENT

- SENSORS, WEAPONS/ARMAMENT, COMM/NAV, DISPLAYS, ETC.
- EMPHASIS ON MULTI-PLATFORM APPLICATIONS - HTI

PLATFORM ELECTRONIC ARCHITECTURE

- EFFECTIVE INTEGRATION OF MISSION SUBSYSTEMS (MS)
- ENHANCE VEHICLE PERFORMANCE WITH EFFECTIVE INTEGRATION OF PLATFORM SUBSYSTEMS AND MS

Helicopter Integrated Low-cost Avionics Demo (HILAD)

- LEVERAGE AF, NAVY, AND DAPRA OSA DEVELOPMENTS
  - ISS/JSF, MAST, VITAL, ETC.
- ADAPT OSA TO ROTORCRAFT UNIQUE REQUIREMENTS
  - NOE ENVIRONMENT
  - FAULT & BATTLE DAMAGE TOLERENCE
  - DIGITAL BATTLEFIELD REQUIREMENTS
- PE 063003 DB97 – AVIONICS INTEGRATION

ARMY TECHNOLOGY THRUSTS
HILAD

REQUIREMENTS

- JTA-A
- COTS
- COMMON MODULES
- PLUG & PLAY
- REUSABLE SOFTWARE

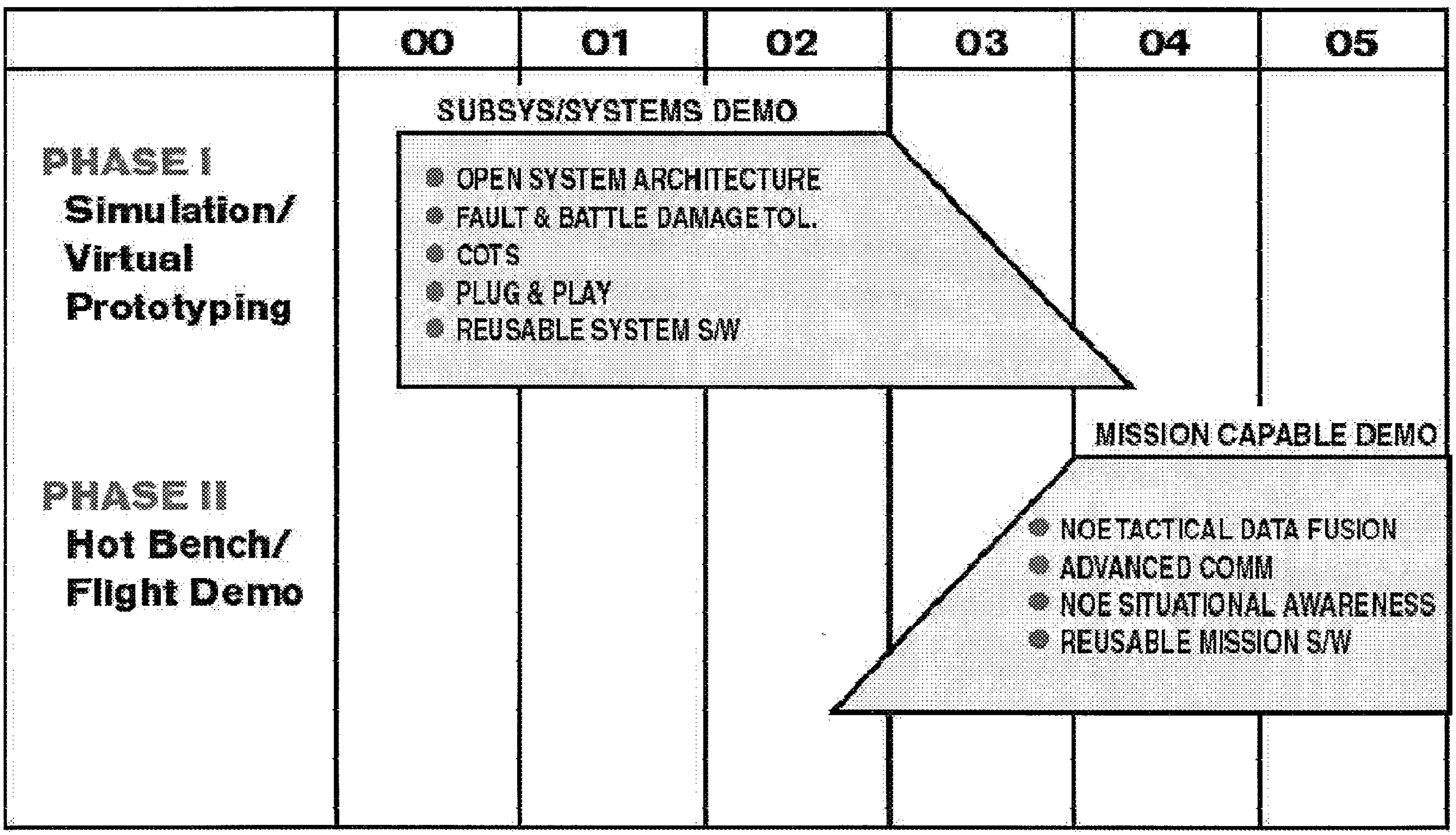
GOALS

- 30% REDUCTION IN WEIGHT, COST, & POWER
- 35% IMPROVED MISSION RELIABILITY & BATTLE DAMAGE TOLERANCE
- 35% INCREASE IN SITUATIONAL AWARENESS & NOE TARGET OPPORTUNITIES
- 50% INCREASE IN OPTEMP ON DIGITIZATION BATTLEFIELD

OBJECTIVE

Develop next generation rotorcraft electronic architecture standards, specifications, avionics interface criteria, and demonstrate emerging integration technologies

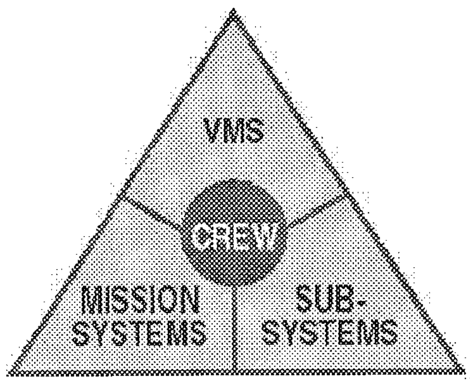
ARMY TECHNOLOGY THRUSTS
HILAD



TI-97-27-16

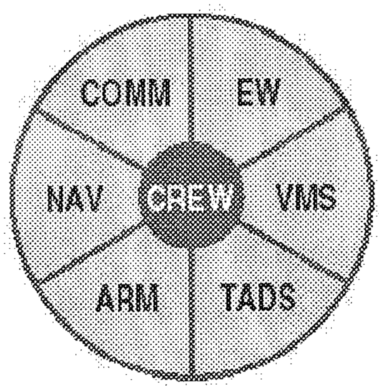
INTEGRATED PLATFORM ELECTRONICS THRUST
AFFORDABLE DIGITAL AVIONICS

TODAY | **TOMORROW** | **ARMY AFTER NEXT**



F-22 RAH-66

INTG/PARTITION



FEDERATED

FA-18 AH-64

MISSION SYSTEMS - JSF/MAST

Open Arch
Reliability
Common H/W-SW
Std Interface
COTS

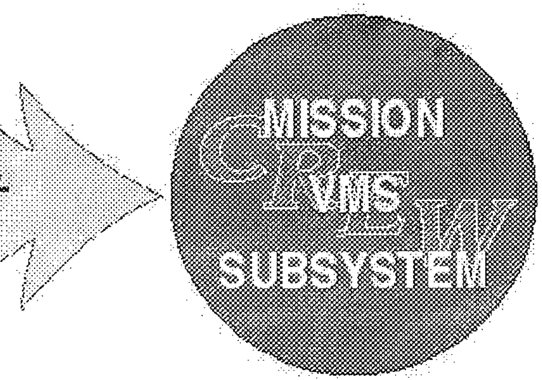
VEH MGT SYSTEM - FLASH/VITAL

Open Arch
Fault Tolerant
Common H/W-SW
Std Interface
COTS

SUBSYSTEMS – MEI

POWER-BY-WIRE

MISSION
FLEXIBILITY/VERSATILITY



REDUCE $
RDT&E, PROC, O&S

P-TI-169/98

971

Title: **Changing Requirements For EW Threat Simulation**

Presenter: **Dr. Edward G. Eberl, Vice President, Amherst Systems Inc.**

Track: **SOS TSG**

Changing Requirements For EW Threat Simulation

1. Introduction

This paper represents my own observations based on recent procurement and contract activity engaged in by Amherst Systems. It is not the result of a scientific survey. No requirement is intended to be associated with a specific system under test or program. These observations are based on many recent requests for proposals and contracts which Amherst Systems has been exposed to. As a leading manufacturer of EW threat simulators for all applications (RWRs, Jammers, ELINT receivers, etc.), Amherst Systems is in a unique position to be aware of many current and future requirements. While we have not won every contract, we have had the opportunity to bid on every major program and thus have been exposed to the most stringent simulation requirements.

1.1. A Few Basics

An EW threat simulator performs three basic functions. The first step is the generation of the radar's transmit waveform. This requires the generation of an RF waveform with the appropriate PRI, frequency, pulse, and scan characteristics. This waveform represents the RF signal as it leaves the transmit antenna. The second function is the modeling of the environmental effects as the waveform travels from the transmitter to the receiver. This model takes into account all factors which affect the electromagnetic wave as it travels from the transmit antenna to the receive apertures on the system under test. The final step is to model the aperture and receiver effects as the waveform is measured by the system under test.

2. Early Simulation Technology

In the infancy of the EW threat simulation industry, there were a few basic requirements to be met. Pulse train generation consisted of simple PRI and pulse width. Geometry and motion simulation was limited to simple straight and level flight in a flat earth environment updated at 1 Hz. A basic radar range equation was used, resulting in a simple 20 log R range loss. The RF signals were typically generated using noisy VCO RF sources with coarse frequency resolution. Modeling of the system under test was implemented by a generic receiver model which generated 4 amplitude controlled signals for injection into an amplitude comparison DF receiver. While all of this may sound quite limited by today's standards, it represented the state of the art at the time. It was also sufficient given the level of sophistication of radar warning receivers at that time.

3. Factors Pushing EW Threat Simulator Requirements

In today's environment, there are several factors pushing the industry to higher performance levels. In recent years, many new simulation requirements have been imposed as a result of the increasing capabilities of the radar system being simulated. Other requirements are driven by increasing sophistication of the EW systems being tested. Another contributing factor is the need to do more testing with smaller budgets. Fortunately, advances in the state of threat for both

digital processing and RF signal generation is advancing rapidly enough to allow threat simulator manufacturers to keep pace with ever increasing requirements.

3.1. Threat Radar Developments

In general, a great deal of work has been done to keep pace with the increasing capabilities of threat radar systems. Recently, there has been much interest in correctly simulating the latest multifunction radars. These types of radars typically use electronically scanned arrays which allow pulse-to-pulse beam pointing changes for the tracking of multiple targets while searching for new ones. Each beam position can have complex PRI patterns or pulse bursts and the changing PRI waveform must be synchronized to each beam position. Other modern radars use complex pulse coding, non linear FM, or phase coding to enhance detection and tracking capabilities. These requirements are currently being addressed and high fidelity simulations of these characteristics are readily available.

3.2. System Under Test Developments

There are many areas where recent developments in the capabilities of the EW systems under test are creating new or more stringent requirements for threat radar simulation. As the EW systems increase their measurement and processing capabilities, there are corresponding increases in requirements for threat simulation.

3.2.1. Increased Receiver Sensitivity

Receiver technology advances have resulted in increased receiver sensitivity for the systems under test. To provide a suitable test environment, a threat radar simulator must maximize the dynamic range of the RF output. The noise floor of the RF subsystem is dictated primarily by the noise floor and dynamic range of the RF source. Digitally Tuned Oscillators (DTOs) typically have lower noise floors and greater dynamic range than synthesizers. Manufacturers of both types of signal sources have recently reduced the noise floors of their sources. There have also been reductions in the phase noise, which new receivers are more sensitive to.

The RF chain used to modulate the generated waveform for transmit scan, range loss, and receiver antenna pattern must balance the distribution of component losses and amplifier gains to preserve as much of the original dynamic range as possible. The utilization of integrated RF components, consisting of amplitude or phase modulators, switched filters, and amplifiers allows the distribution of the gain to be optimized. After the dynamic range of the signal has been maximized, it must be properly positioned by tuning the maximum output power level. In the past, the emphasis was on providing maximum output power. Recently, there has been more emphasis on lowering the noise floor, at the expense of a reduction in maximum output power. As receiver sensitivity increases and the measurement capabilities of the receiver improve, EW systems are being tasked to perform additional functions where the lower noise floor is of greater importance than higher output power. (In some cases, special EW simulator test configurations are used to perform high power saturation of receiver front ends.)

Increased receiver sensitivity also results in higher emitter/pulse density requirements. The lower sensitivity allows the receiver to detect emitters at greater ranges, bringing more signals into the field of view. In addition, more sidelobe and backlobe pulses will be detected. This requires more emitter pulse generation capability in the digital generation subsystem. Distant emitters must be fully simulated to maintain coherency, even though there may only be a limited number of pulses from the main beam which are above threshold. Increased pulse density also requires more channels in the RF generation subsystem.

3.2.2. Sophisticated DF Systems

Major improvements are being made in the DF measurement techniques and capabilities of modern EW systems. Several simulation enhancements are required to provide adequate testing of these new capabilities.

3.2.2.1. Improved Motion Models

The geometry updates for platform motion increase as EW receivers measure angle of arrival to greater accuracy. In order to avoid having an emitter jump more than one angle cell between motion updates, geometry calculations must be performed at higher rates. In some cases, motion and angle of arrival modulation must be updated at rates as fast as 1000 Hz. In addition, a full 6 degrees of freedom is required to provide a proper angle simulation as an aircraft performs highly dynamic maneuvers. Testing the ability of an EW system to maintain emitter tracks during such maneuvers requires highly accurate motion models.

3.2.2.2. Doppler Modeling

Some newer EW systems utilize Doppler effects to measure angle of arrival through the use of sophisticated processing algorithms. To support testing of this capability, it is necessary to simulate both PRI and RF shifts due to the relative motion of the emitter and system under test platforms. The range delay time changes as the distance between the two platforms changes, inducing small variations in the PRI from pulse to pulse. Simulation of this effect, known as PRI Doppler, requires extremely precise pulse timing in the nanosecond range. The closure rate between the two platforms also generates frequency Doppler. Very high precision RF sources are needed to simulate these pulse to pulse variations in frequency.

3.2.2.3. Simultaneous Phase and Amplitude

Some new receiver systems are making use of simultaneous measurements of relative phase and amplitude at several apertures to compute angle of arrival. Testing this capability requires both phase and amplitude modulation components in the RF path for each receiver port. In addition to the algorithms required to compute both phase and amplitude simultaneously, it is also necessary to account for the incidental phase shift of the attenuator and the incidental amplitude variation of the phase shifter or vector modulator. In systems which require only phase or amplitude control, the incidental effects are not significant. However, when both characteristics must be controlled in the same RF path, these effects become extremely important, especially in light of tighter accuracies needed for compatibility with current receiver capabilities. Compensation for these effects requires sophisticated multi-step calibration algorithms.

In addition, new receivers are using increased numbers of apertures to provide more precise angle measurements and to allow multiple functions, such as signal detection and precision direction finding, to be performed simultaneously. To support this, a more modular architecture which provides more parallel processing is required. For a receiver with dozens of apertures, it is impractical to compute all of the required phase and amplitude values at a central point. An added benefit of a more distributed architecture is that the design is more easily scaled to a specific system under test configuration.

3.2.2.4. Polarization Modeling

Some new EW systems are making use of apertures with both vertical and horizontal polarization, rather than circular polarization. Complex aperture modeling is required to properly stimulate each aperture. For each emitter, the polarization orientation of the transmitted waveform must be matched against the vertical and horizontal response of each receive aperture. Figure 1 shows the transmitted wave vectors and receive aperture vectors and how they are combined mathematically.

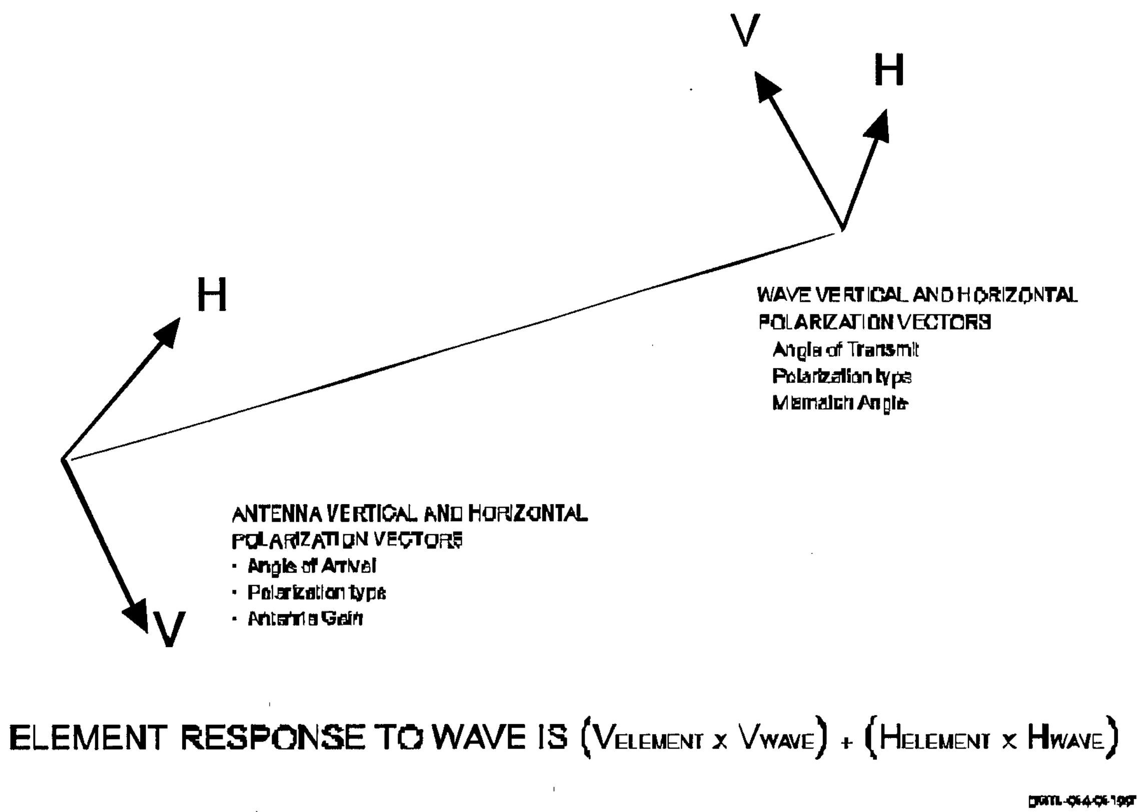


Figure 1

The pulse to pulse orientation of both the transmit and receive platforms must be accounted for in the calculation of the relative orientation of the transmitted waveform at the receive aperture. Figure 2 illustrates how the orientation of the wave relative to the receive aperture is determined.

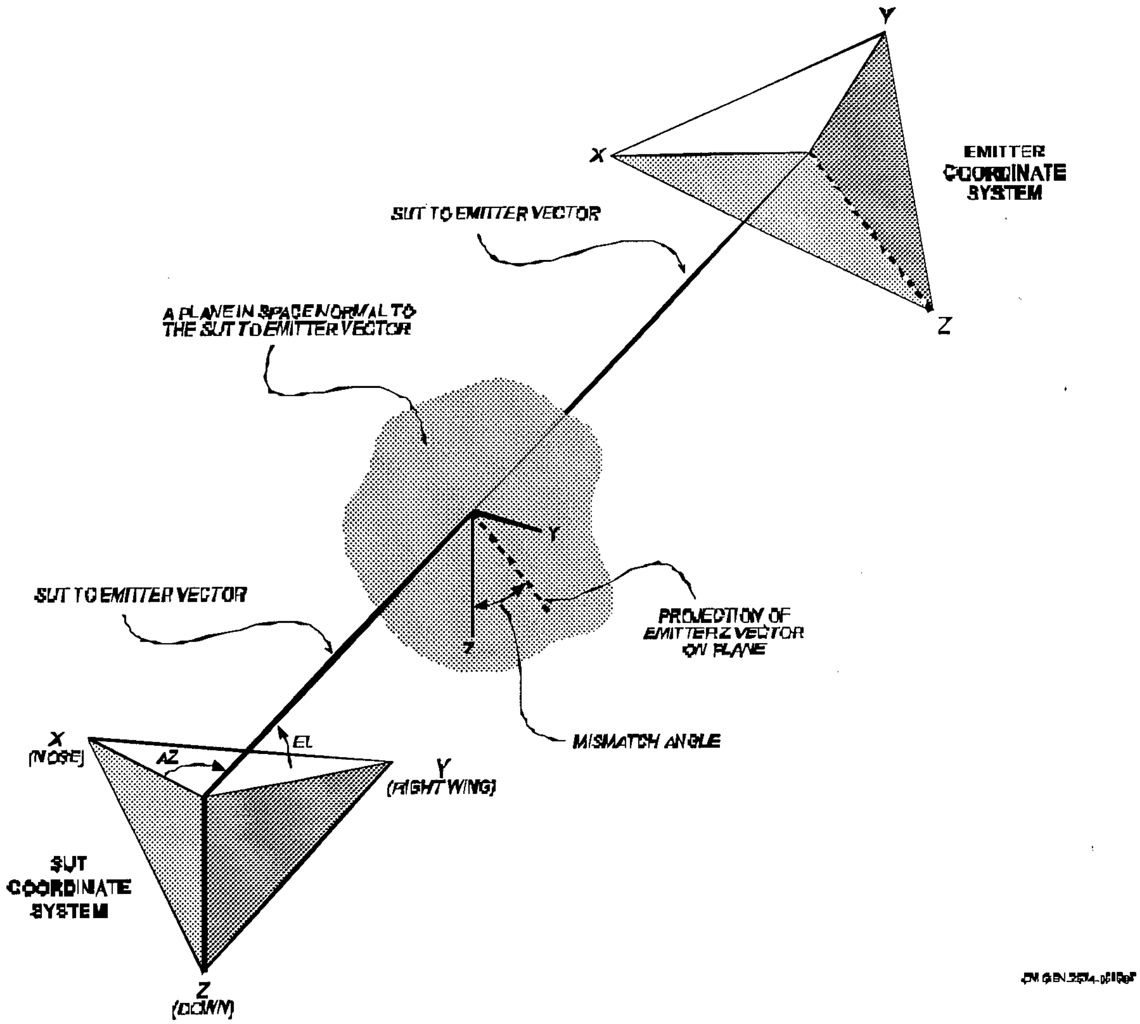


Figure 2

In some cases, measured data shows that transmit polarization varies significantly outside the main beam and this must also be accounted for through the use of a full three dimensional polarization model.

3.2.2.5. Time Difference of Arrival

Another emerging technology is the use of time difference of arrival for direction finding. This requires precise pulse timing control for each receiver aperture. Typically, timing is required to one (1) ns resolution, with a maximum variance from port to port of 150-200 nsec. For normal angle of arrival simulation, the generated pulse is split into several paths, one for each receiver aperture, and then phase or amplitude modulated as a function of the geometry. In this case, the leading edge of the pulse is delayed, leading to corruption of any intrapulse characteristics of the generated pulse. An analysis of the most common intrapulse modulations leads to the conclusion that preservation of bi/quadphase modulation is desirable, and can be included at an acceptable cost. The timing delay from one receiver aperture to another may be large enough that an entire phase modulation bin would be eliminated from the pulse. Systems looking for specific modulation pattern content would detect different patterns at different ports. On the other hand, typical chirp and FMOP modulations are such that elimination of a small portion of the leading edge of the modulation is not significant to the receiver. The same is true of most AMOP

modulations. Of course, the technology to preserve all intrapulse characteristics is available, but at significant cost. For most systems, inclusion of separate frequency and amplitude intrapulse modulation elements for each receiver aperture is not required. Where pulse rise and fall times are controlled for each emitter, this characteristic must be preserved for each receive aperture.

3.2.3. Receiver/Processor Capability

As with many things, the processing capability of EW systems is increasing dramatically. As a result, modern EW systems have increased track file size and are expected to handle environments with higher emitter/pulse densities. Threat radar simulators must be able to provide these additional densities to stress the processing capabilities of these new receiver processor systems. Another application of the increased processing capability is the utilization of precisely measured pulse times in sophisticated algorithms to identify the underlying clock characteristics of a specific radar. In support of this, threat simulators must be able to model crystal count-down techniques for PRI generation with extreme precision and must be able to control pulse start times to one (1) ns or less.

3.2.4. Integrated EW Suites

As EW suites become more integrated, it is necessary to provide threat simulators capable of stimulating apertures for multiple receivers simultaneously. Separate outputs may be required for an RWR, a jammer, and an ESM system. While no one system may have a large number of apertures, taken together, an integrated suite can easily have upwards of 40 apertures. Also, the different systems may use different direction finding techniques, including amplitude, phase, time difference of arrival, or a spinning antenna. The threat simulator must be capable of modeling each different direction finding technique simultaneously for each pulse. A distributed processing architecture again becomes critical to supporting this requirement. In addition, the various subsystems of an integrated suite quite typically communicate with each other over a standard bus. To support development and testing of individual subsystems, it may be necessary for the threat simulator to provide a simulation of bus message traffic. For example, testing a jammer may require generation of message traffic normally provided by the radar warning receiver.

3.2.5. Sensor Fusion

Sensor fusion is a growing element of modern electronic warfare. With Sensor Fusion, there may be several sensors, including a communications receiver, radar, EW receiver, and an IR sensor, which all detect and characterize various target signatures. Higher level software attempts to correlate detections from each sensor in order to increase confidence in target identification and location. A true multispectral stimulus is required to support testing of the fusion algorithms. A coordinated environment, including precise time and motion synchronization must be presented to each sensor. Each player must appear at same time for each sensor, and each sensor must see the player at the same location. There may also be a need for informational synchronization, where signatures with message content accurately represent the environment being simulated. This requires the ability to program a common scenario for all of the stimulators, and each stimulator must be capable of accepting precise time synchronization from a master control during a real time simulation.

3.3. Multipurpose Laboratories

As laboratories are consolidated, there is a growing need for a single laboratory to support multiple systems under test. It is no longer cost effective to have simulator systems configured to support a single receiver configuration. The simulator must provide reconfigurable test assets which can be rapidly reprogrammed to provide phase, amplitude, or time difference of arrival modulation for each output port. In addition, it is desirable to have a flexible architecture where the interconnection of RF generators and angle of arrival modulation assets can be changed to provide a higher channel density with fewer output ports, or higher number of output ports for a

reduced number of channels. This allows a laboratory to be readily configured to meet changing test requirements and receiver configurations.

3.4. Training Applications

Training applications for EW threat simulators are expanding rapidly. There is growing interest in stimulating real avionics rather than modeling the function of the avionics in a trainer. This is true for both on board trainers for ships and classroom trainers. Software models of an EW system require extensive validation and constant updates as the EW system is improved. The use of actual EW system hardware eliminates the validation step, and provides a more realistic training environment. It is not always necessary to stress the processing capabilities of an EW system for a training application, creating a need for smaller simulator configurations which still provide full emitter fidelity. This is especially true for on board trainer systems. Also, digital injection can provide a more cost effective means to utilize actual avionics as part of a trainer. This requires a digital model of the receiver front end, but eliminates the need for expensive RF generation subsystems and also eliminates the need to have the actual system under test receivers present. Distributed training applications also require threat simulators which can support real time control interfaces using Distributed Interactive Simulation (DIS) or High Level Architecture (HLA) protocols.

3.5. Shrinking Flight Test Budgets

Flight test budgets are shrinking, placing more emphasis on laboratory simulation. To support this, there is a need for higher fidelity simulation of environmental factors such as terrain masking, multipath, ducting, weather effects, and wave splashover. All of these characteristics are present in range testing or sea trials. In order to be more reliant on laboratory testing, these environmental effects must be accurately modeled. This provides higher correlation between laboratory results and flight test or sea trial results. As the correlation between the results from the two forms of testing increases, the value of laboratory testing will increase, and more aspects of system performance can be characterized and verified without costly flight testing.

3.6. Range Applications

Modern EW ranges require greater flexibility. There is a need for dual use ranges, which can support both test & evaluation and training requirements. For training applications, it is desirable to have a training range integrated with an EW simulation. For these applications, an EW threat simulator can be used to model the transmit characteristics of a threat radar. A measurement receiver can be used to detect jamming signals from the aircraft being illuminated to support model based reactive emitter control. A major benefit of adapting an EW threat simulator for range use is rapid reprogrammability, where a single threat site can be used to simulate multiple radar sites during a single training exercise or test. To maximize the flexibility of each threat site, wider band transmitters are used, with some tradeoff in output power. This also provides the capability to simulate multiple emitters from a single site, providing a cost effective increase in signal density.

3.7. Support Tools Software Environment Generator

As the capabilities of threat simulators have grown and environment densities have increased, there has been a higher demand for enhanced support tools. A major emerging requirement is the need for automatic dynamic scenario generation. These scenario generation tools allow the user to specify an initial threat laydown and rules of engagement which are then processed by an engagement model. The model may use either a predefined flight path for the system under test platform or it may allow a man in the loop to fly the system under test. As the system under test platform moves through the environment, the engagement model controls emitter activity according to the previously specified rules of engagement. The engagement model facilitates generation of realistic dynamic scenarios and allows multiple flight paths to be analyzed for scenario density and EW system performance.

In the interest of maximizing the utilization of simulator assets, there is a growing need for non-real time signal generation and analysis tools. These tools allow the operator to use a software model to generate a pulse by pulse representation of a scenario and save the results in a disk file. This can be done on a stand alone workstation without tying up the simulator hardware assets. Once the pulse file is created, analysis tools can provide RF signal characterization, density computation and graphical plots of pulse trains which can be used for emitter programming verification. In addition, pulse density analysis tools can be used to predict system throughput, pulse contention and dropout. These predictions can be used in RF configuration and scenario tuning to optimize simulator performance. Figure 3 shows an example of one of the several analysis tools available. This tool calculates a scenario emitter or pulse density as a function of time, frequency, AOA, amplitude or several other user-specified parameters

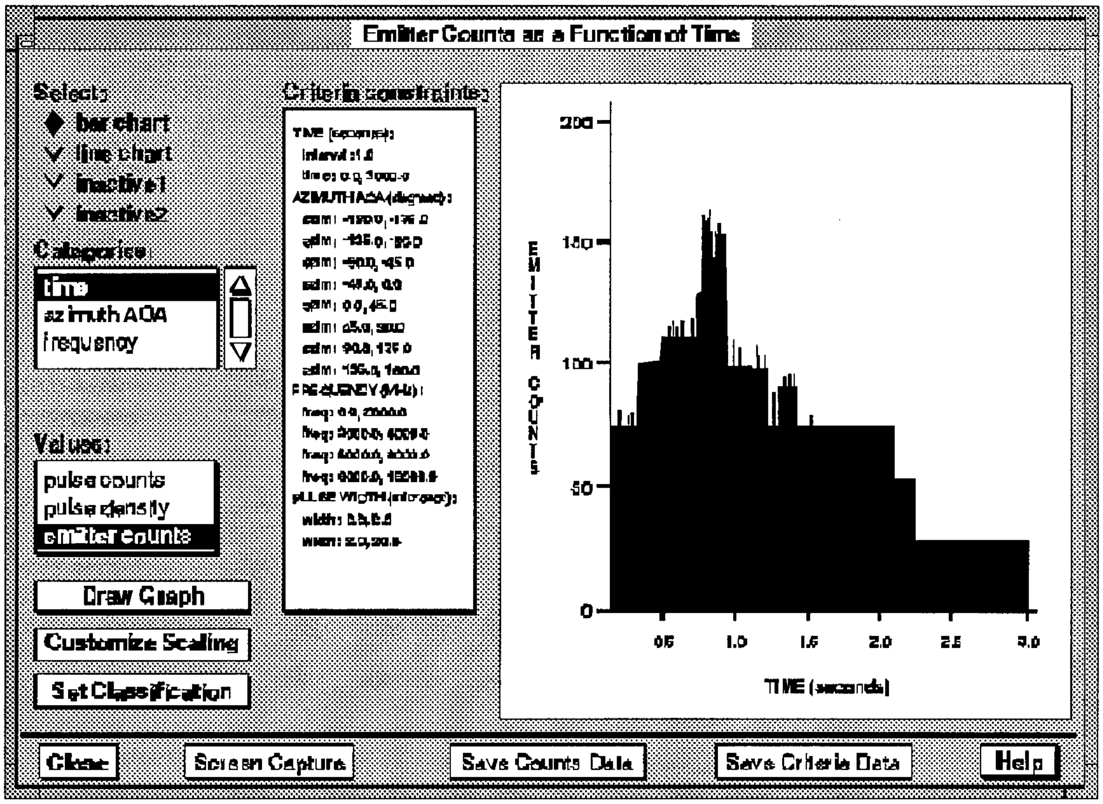


Figure 3

3.8. Integrated Simulator Applications

As laboratory simulations become more sophisticated, there is a need for real time interfaces for laboratory integration. These interfaces may include ownship navigation control, platform control and emitter control. The host processor may be running a higher level SUT simulation or utilizing real time engagement or performance models to generate real time scenario changes. Real time interfaces may also be used to support a man in the loop flight simulator. These types of applications require the threat simulator to react to external inputs in order to provide a truly reactive environment. Other applications require remote scenario monitoring by a host computer. Trainer systems may utilize a real time interface to the instructor station to support real time changes to the training exercise and monitoring of student performance.

3.9. Monitoring and Analysis

There is growing interest in monitoring and analysis tools to aid users in the verification of simulations and analysis of system performance.

3.9.1. Signal Generation Verification

In any test situation, there is a need for "truth" data, a record of the actual test stimulus that was generated. This is needed to verify that the correct emitter waveforms were generated and to monitor simulator performance. Truth data may be recorded in the form of digital pulse descriptor words which can be post processed for performance analysis. This form of data is useful for detailed analysis of pulse train generation and simulator throughput. Another form of truth data is generated by a real time signal measurement system. This system captures, analyzes, and records the actual RF output of the threat simulator. This provides verification of signal generation at the final outputs of the simulator for maximum confidence.

3.9.2. SUT Performance Analysis

When a system under test is subjected to a dense dynamic scenario stimulus, it is not feasible to determine EW system performance manually. There is a need for analysis tools which can automatically correlate the generated stimulus to the characterization of the environment made by the system under test. Truth data recorded by the threat stimulator provides one input to the correlation process. The other input can be provided by re-recording emitter reports or similar data available on standard busses within the system under test. Additional data may be in the form of real time measurement of actual ECM outputs generated by a jammer system. The simulator truth data and recorded system under test data are correlated to determine correctly identified emitters, time to detection, accuracy of measured parameters such as frequency or angle of arrival, missed emitters, and false emitter reports. These results can be analyzed statistically or presented in graphical form to determine quantitative performance of the system under test.

4. Summary

EW threat simulation capabilities must meet ever expanding requirements. These requirements are the result of the increasing capabilities of threat radars and the increasing detection and processing capabilities of EW systems. Other factors influencing emerging requirements include the need for higher fidelity simulation capability to provide closer correlation between laboratory testing and flight testing in order to allow greater reliance on laboratory results. To meet these requirements, a new generation of EW threat simulators must make use of state of the art technologies, including modular scaleable architectures, high speed DSP/RISC processors, and integrated RF subassemblies. Advanced software models are needed for scenario effects including platform motion, direction finding modulation computation, and environmental models. Significant investments by both EW threat simulator manufacturers and users are required to keep pace with these changing requirements.

Title: **The Simulation Challenge within a SIL Test Environment, the EWAISF**

Presenter: Mr. Jerome M. Smith

Track: SOS
Day:

Keywords: simulation, threat files, development process, testing, SIL

Abstract: This paper will focus upon the challenge of transforming intelligence and system information into adequate simulation test files within a Systems Integration Laboratory (SIL) environment. The purpose of the simulation is to facilitate development and testing of electronic warfare systems. The paper will provide a discussion of the challenge, a process of handling the challenge, the technology employed and/or is necessary, and a relationship among process, people and technology.

The Simulation Challenge within a SIL Test Environment, the EWAISF

Possessing adequate simulation is a challenge that must be met to allow reaping the benefits of new acquisition and test strategies. This challenge is not unique to System Integration Laboratories (SILs). This discussion will focus upon the simulation challenge within a SIL test environment. The simulation challenge concerns three aspects: 1) the acquisition of the necessary data or information, 2) the implementation and use of data in creating resultant simulation work products, and 3) retention and dissemination of data and simulation products.

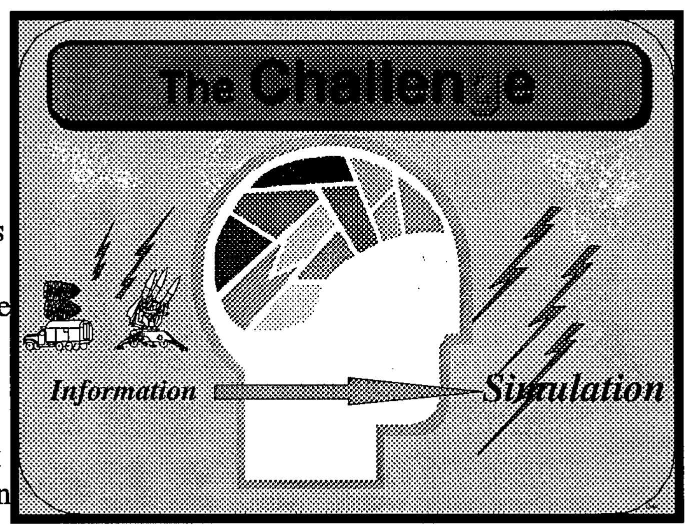


Figure 1

1.0 The EWAISF

The ElectronicWarfare Avionics Integration Support Facility (EWAISF) is a government facility which serves a dual role as an Air Force commodity electronic warfare systems management

& software support center and as a system integration laboratory (SIL) for the electronic combat test community. Simulation of threat emitters or signals has always been a part of the software change development and testing process methodology. A high level overview of the electronic warfare software support process flow is as follows: As one or more external factors (such as threat changes, a change in tactics, a change in system hardware, a need to enhance system performance, or a need to satisfy logistical requirements) occurs, the change process starts. New or updated requirements are provided to the EWAISF team. The requirements are processed within the EWAISF in order to develop the electronic warfare system software change and the required test simulation. **Threat simulation** is used in a series of informal and formal tests including code debug, mission data, integration, verification & validation and kitproofing. After the resultant change is formally released by a configuration board, the change is distributed and then installed into the aircraft which allows a more mission capable posture. A typical EWAISF Integration Support Station (ISS) laboratory configuration is shown in figure 3. This configuration consists of actual electronic warfare system hardware, computer hardware and software, and simulation.

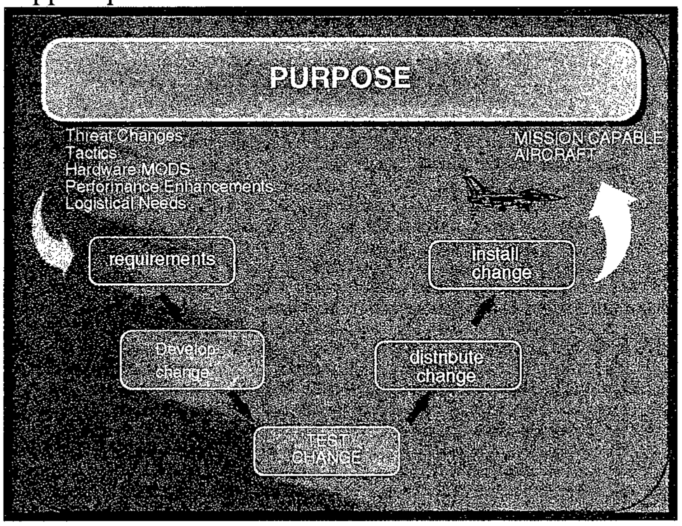


Figure 2

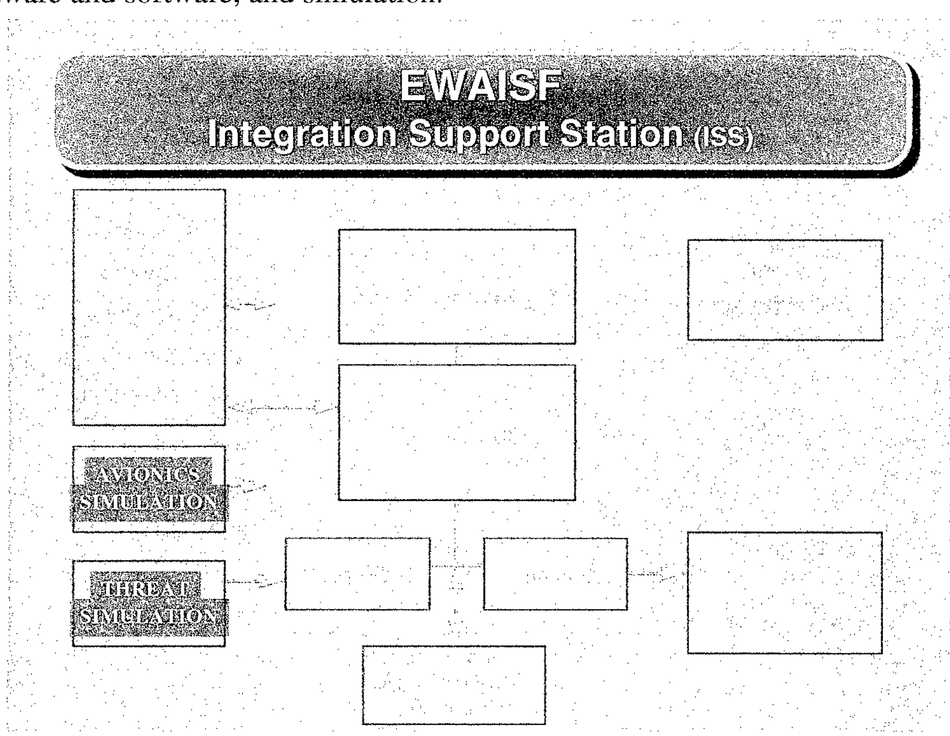


Figure 3

2.0 Our Simulation Process and Technology

The EWAISF simulation process has a goal of producing adequate threat simulation files in support of electronic warfare systems support. How we meet the simulation challenge could affect several of the Air Force's Core Competencies. The core competencies are part of the strategic vision and plans of the Air Force in the 21st Century. The core competencies are Air and Space Superiority, Global Attack, Rapid Global Mobility, Precision Engagement, Information Superiority, and Agile Combat Support. The competencies are tied to knowledge, expertise, and technological implementation that, when properly applied, produces superior military capabilities.[1] Our simulation process is dependent upon information, applied knowledge, threat expertise and software & simulation technology innovation. The basic aspects of our simulation process are 1) effective process methodologies & technological innovation, 2) expertise base, and 3) key process participants.

The *IDEAL*

If we operated in an ideal situation, the input information and data requirements would be timely received, comprehensive and technically appropriate. Our implementation or utilization phase would be characterized by perfect management, manipulation and use. The resulting product would be always providing the right quantity, exhibiting absolute technical correctness and, of course, providing perfect utility.

The *REALITY*

Our operating environment does not conform to the ideal situation. We wrestle with a complex "wicked problem". "Wicked problem" as defined by E. Jeffrey Conklin and William Weil in their paper **Wicked Problems: Naming the Pain in Organizations**, defines a wicked problem having the following attributes: 1) evolving set of interlocking issues and constraints; 2) there are many people and organizations that are affected or care about the resolution; 3) constraints are present and can change over time; and 4) difficult to definitize.[2] Our reality, I believe can be categorized as being "wicked". The elements of our "wicked problem" is shown in figure 4. Schedule is rarely simulation friendly; results are wanted **NOW**. The simulation must be accurate and with a high degree of fidelity. Cost, resources and technical requirements constraints can change over time. There are many players, officials, and spectators. Warfare is often difficult to thoroughly definitize and bound the tasking. The necessary inputs can include technical, program, and strategy elements. Data

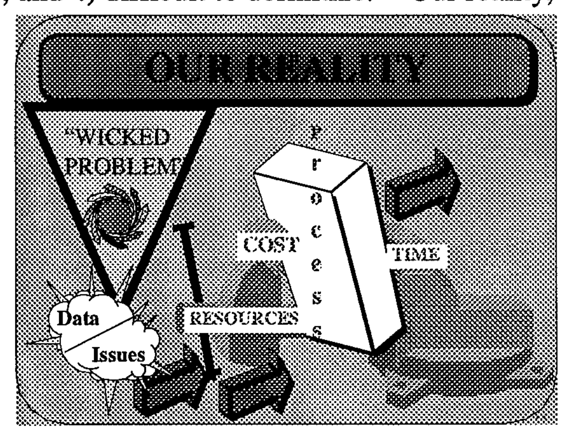


Figure 4

[1] **Global Engagement: A Vision for the 21st Century, Core Competencies**--http://www.xp.hq.af.mil/xpx/21/core.htm.

[2] **Wicked Problems: Naming the Pain in Organizations, E. Jeffrey Conklin & William Weil**--http://www.gdss.com/wicked.htm

complexity can range from simple bits to aggregate volumes. The data may be random or organized. We concentrate upon the engineering model level of the simulation spectrum. We are most active in the production, fielding/deployment and operational support phases of the acquisition lifecycle. Our process consists of three subprocesses: 1) the definition phase, 2) the implementation phase, and 3) the application phase.

The Definition Phase

In the definition phase, we accomplish the design of the simulation. Arriving at a technical visualization, as pictured in figure 5, is dependent upon several factors. At the programmatic level, there is the dissection of the requirements to provide an estimate of the simulation effort in respect to time, cost and performance constraints. Technically, the simulations to be designed are dependent upon 1) operational characteristic and compositional data and 2) simulator platform parametric mapping. Our data concerns include accuracy and currency of the information. Also, the data must be understandable and reasonably presented, identified, and properly correlated with associated data. Simulator platform parametric mapping involves determination of complexity, trade-off options, fidelity requirements, and other requirements and constraints reconciliation. We do not operate in an "one size fits all" environment. The EW system platform, the system under test, or the test objective can also tailor the simulation design. In our environment, there are many simulation components. These include specific signal characteristics that are platform, system, or subsystem related as shown in figure 6. The required simulation may be a single beam of an One-on-One situation, multiple single beams of different emitters, multiple beams of one or more emitters, or a Many-on-One situation. The situation could be a static test case or a time scenario involving events and/or spatial movement. The test case may require that other signals other than EW signals be present. Our basic building block is the **MODE**. Systems to be simulated can have seemingly infinite operational modes. It is not possible given our operating constraints to deal with all instances. We select our simulation candidates upon the following considerations (figure 7): 1) our customer's (user) information such as mission, role, and expected operational environment of the EW system(s); 2) system information such as threat reaction and

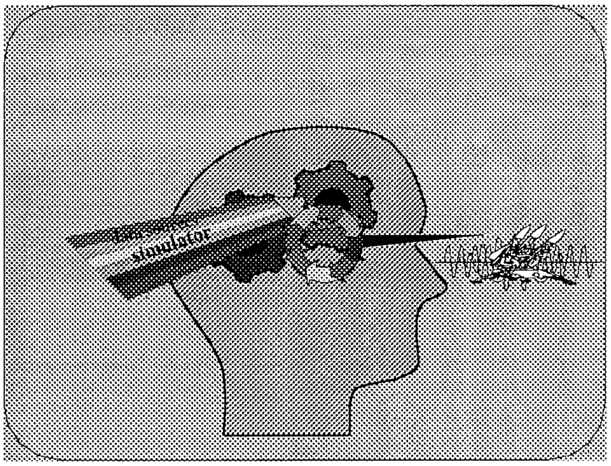


Figure 5

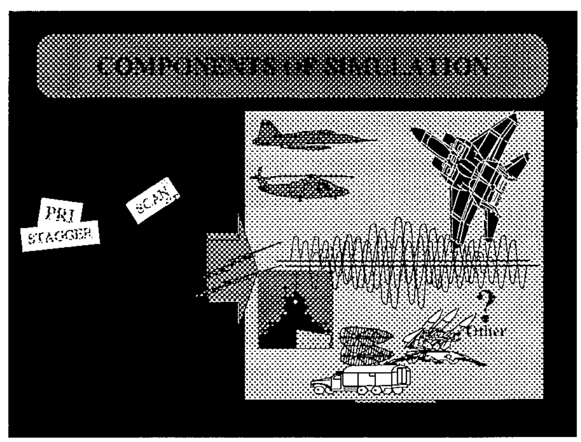


Figure 6

operating characteristics; 3) EW system information such as spectrum coverage, receiver & processing implementation, mission programming, and display options; 4) the strengths and limitations of our simulators; 5) and, of course, inherent educated and experienced mental activity. The threat data, the various parameters or signal characteristics, of a particular simulation candidate are defined and developed into a threat definition which will result in a simulator file in the implementation phase. The parameters are properly assigned to create the individual mode. Our mode (simulation definition) may be different from another mode in only one critical parametric. Some modes are related to others and we maintain that relationship through the definition and the implementation of the simulation. A summary of our definition phase is as follows: 1) characterized by data acquisition and manipulation; 2) is dependent upon logic and visualization, presently largely a human tasking; and 3) needs automation further than the employed database technology.

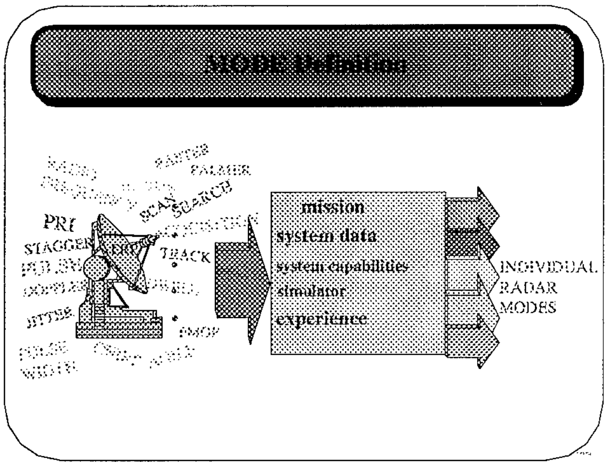


Figure 7

The Implementation Phase

Departure from the definition phase means that we are confident of knowing the requirements adequately; of the simulation design to produce adequate modes; and of our simulator(s) to accept the definition. The purpose of the implementation phase is to translate the definition from a design to a simulation file capable of being used. Figure 8 shows our technology attempt to assist the simulation definition and implementation phase by automation.

PC workstation software procedures networked to simulator controller to simulator RF subsystem.

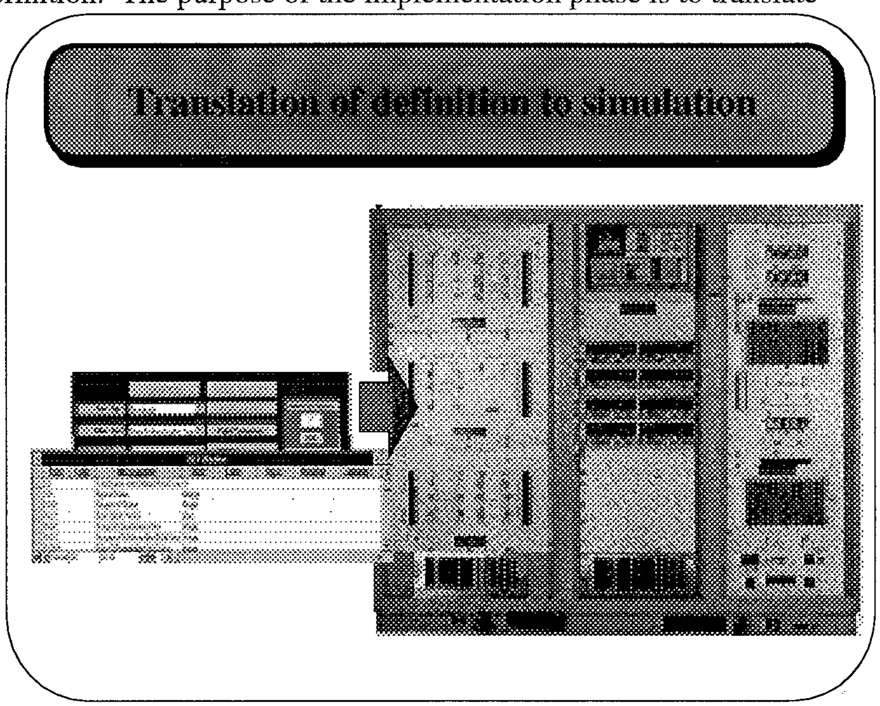


FIGURE 8

Our implementation process consists of three subprocess steps and one major decision step. The first step is called **parametric entry**. A simulation definition can be quite complex and require a large number of entries of data and data sets. Currently, we employ both manual and "automated" means of populating the simulator's file formats. This step requires a high degree of accuracy and associated data manipulation skill. Communication between the simulation designer and the simulator implementer is necessary. The second step consists of two parts, **execute and measure,** begins after the simulator is populated with the simulation definition. We execute in real-time the simulator file and measure the critical parameters. In this step, we find out if the definition is acceptable to the simulator. This part involves the simulator technician (implementer), the simulator, the definition, test equipment. The second part, **analyze**, follows or is performed concurrent with the execute and measure action. This action involves processing data to assist in answering the questions whether the simulator file is accurate, whether the file operates correctly, and whether any outstanding or unexpected limitations were found. Communication between the simulation designer and the simulator implementer is important. The third step, **evaluate**, is the action which answers the questions and determines the next action to take. The choices include: 1) is an adjustment needed to the simulation, 2) does the simulator's software or hardware need attention, or 3) the simulation meets criteria. The decision step, **accept**, involves: 1) simulation is available for testing use and 2) simulation becomes an item for our threat library procedure. Our library procedure requires constant information source awareness and continued partnerships. As part of our library procedure, the simulation files are reviewed and kept current. Feedback from testing use is also important. A pictorial of the implementation process is below in figure 9.

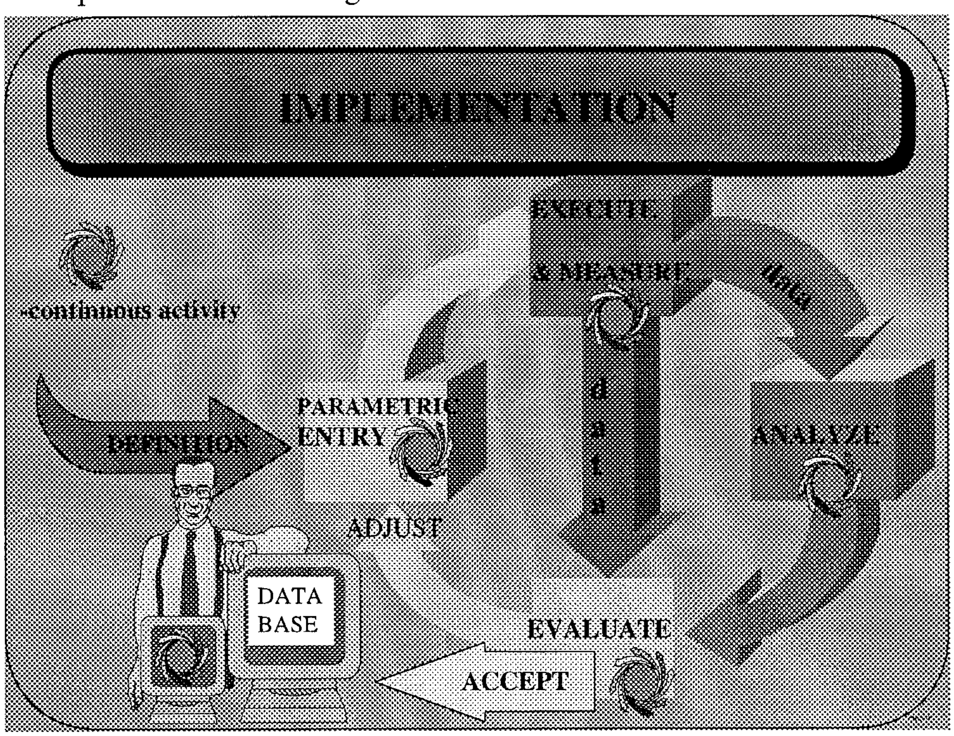
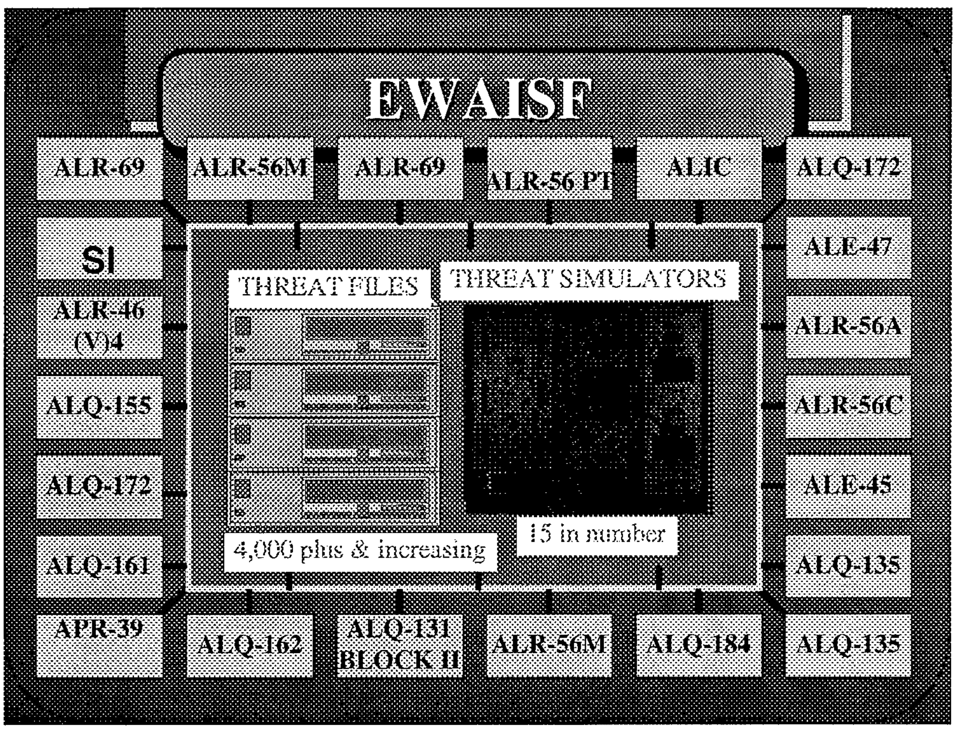


Figure 9

The Application Phase

Before discussing the application phase, some more background information about the EWAISF, test operations, and simulator database will assist. The simulation and evaluation branch supports a number of EW systems. Any or all may need critical simulation support. We operate in what can be described as "prime time" and in an environment in which demands expert performance. In the EWAISF, there are a number of threat simulators (over 25) mainly in the radio frequency (RF) spectrum. In support of the EW systems, we have over 4,000 simulation files replicating modes of about 510 threats. In addition, we support these EW systems with other required test stimuli. Figure 10 gives a pictorial view of the EWAISF in block diagram form with our networking and key elements.



Systems, threat database, threat simulator (RF subsystem), classified and unclassified nets.

Figure 10

The basic building block for the EWAISF is the Integrated Support Station (ISS). ISSs exist within the EWAISF to support software change development, test, and other system support activities. The heart of each ISS is the EW system which is implemented as hardware, simulated or hybrid entities. Simulation capability, especially threat simulations, is an important component of each ISS and our test methodology. Figure 11 shows in block diagram form the composition of an EWAISF ISS. Brief description of each component is as follows: 1) The EW UUT -- the component which includes the hardware, firmware and software of the EW system (unit under test). In our implementation, not all EW system components are necessary. 2) The EW UUT Control -- this component may be the EW system's own processor(s) or a separate computer which allows controlling system functioning. 3) The EW UUT Monitor -- this

component is specialized and general test equipment which provide instrumented data collection and analysis capability. 4) Simulator -- component which provides the Radio Frequency (RF) threat environment. We also have one IR threat simulator. Our current threat library is mostly in the RF spectrum. 5) Avionics Simulation -- this component provides other signals such as navigational data . 6) Test Control -- The function of this component is to provide some level of automated test sequencing and scoring of EW system performance. The concept is in the third phase of implementation in the EWAISF. 7) Simulation Design Assistant -- This component is to provide some design and implementation assistance for threat simulations. In this effort, we have completed a concept demonstration. 8) Process Monitoring & Control -- This component is to allow enhanced event correlation and time synchronization and to provide RF threat simulation status and parameter monitoring. Automation of this component is being pursued. 9) Timing Reference -- Component to establish basic timing synchronization between the ISS components. 10) Computer networking, databus, and RF cabling -- this component provides for both classified and unclassified information transfer. This figure (figure 11) is related to figure 3 in that figure 3 shows a view of the EW UUT.

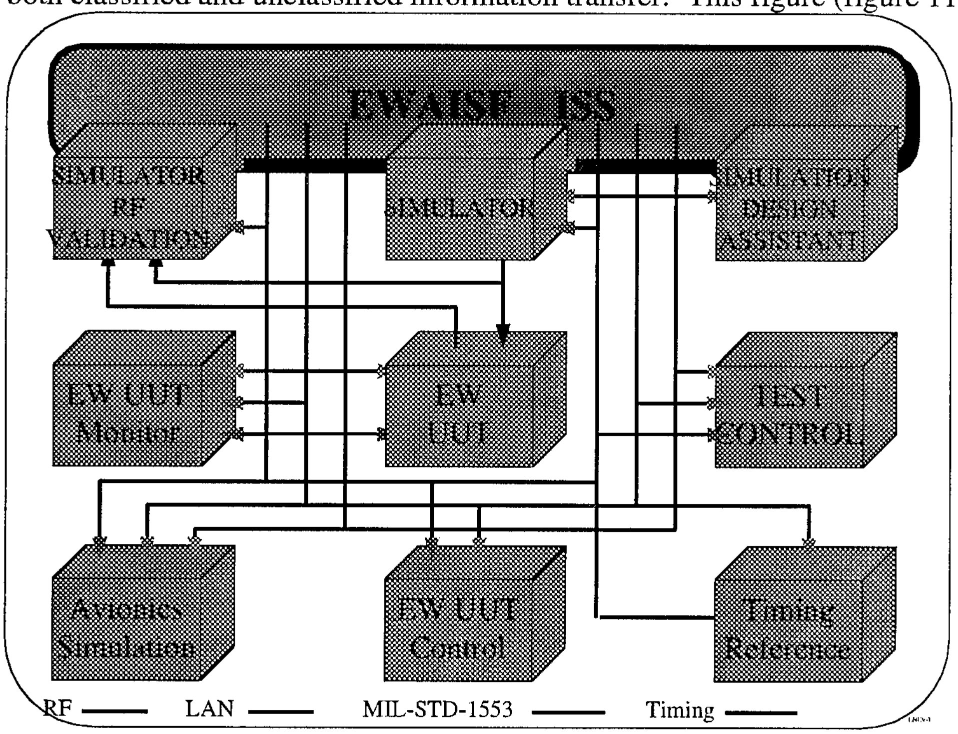


Figure 11

Application Issues

In our test methodology, the focus is whether the simulation files are suitable to provide the stimuli in order to test the EW systems. In preparing for an EW system test, our first question to be answered is does a simulation file exists? If not, we initiate the definition phase.

The next question is how dated and accurate is the simulation? We must operate with the latest and with highest possible accuracy. The third question is there any "side effects" due to simulation tailoring? We are concerned with proper scoring of EW system performance due to any testing limitation. Lastly, we are concerned with proper testing execution. Is the simulator

operating within the design tolerances of the simulation file and of the simulator's hardware and software? Figure 12 is a pictorial overview of the application phase. The inputs are 1) a programmed simulator, 2) engineering documentation of the simulation, and 3) test documentation (plan, procedure, and predicted results (for automated scoring)). This phase utilizes execution of simulation test files and evaluation of system response data. There is much communication and interaction among the test engineer, the simulation implementer (simulator technician), the simulation designer, the EW system engineer, and, often, the customer. We are striving for a level of automation in the execution of our testing; however, there is still much value for maintaining the human test factor.

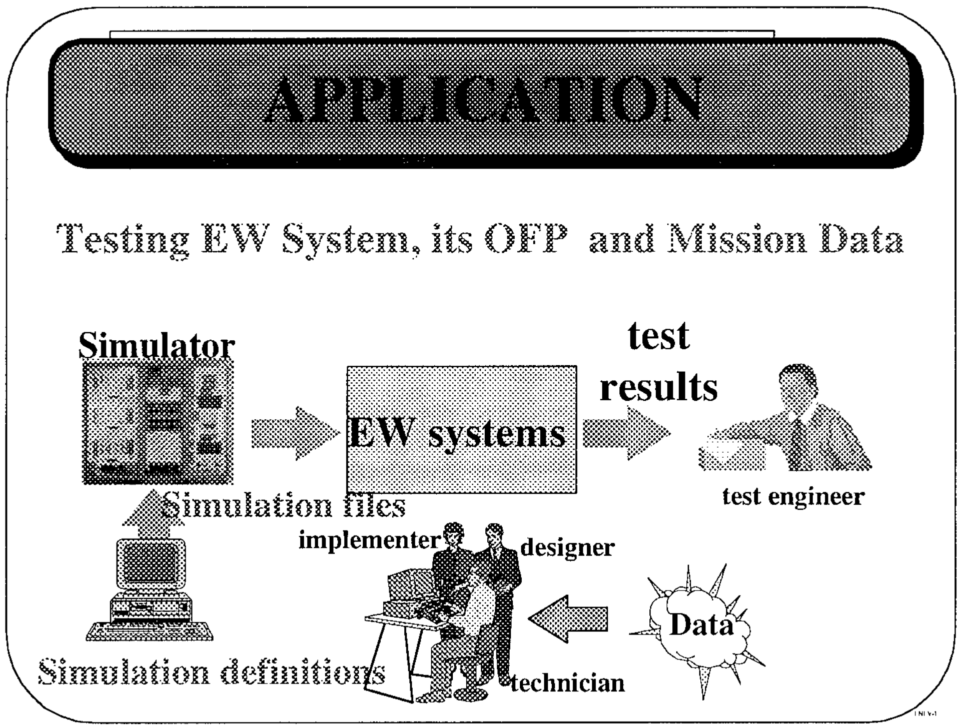


Figure 12

3.0 Keys to *SUCCESS*

Developing and using simulation files successfully depends upon three distinct items:

effective processes & technological tools,
skilled personnel,
and active intelligent partnerships.

The three components do not have to be equal but there is a proper **balance**.
Unbalance in any area creates difficulties and constraints and intensifies the simulation challenge.
The three components are necessary simulation basics.

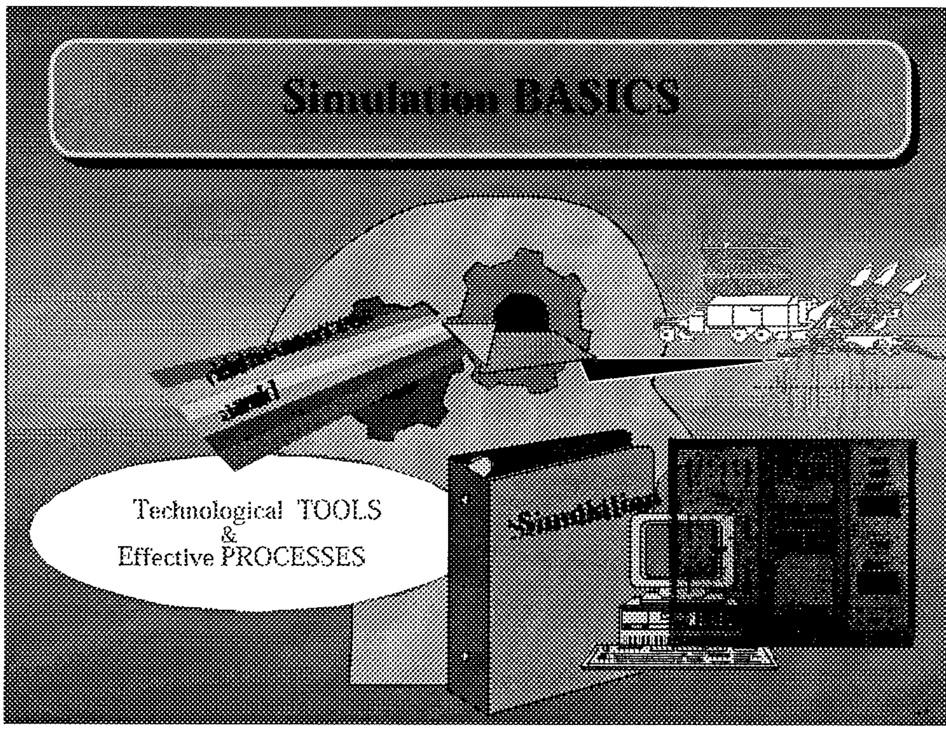


Figure 13

Effective Processes & Technological Tools

Without an effective process and the technological tools to accomplish the process steps, data acquisition and manipulation, simulation definition and design, and simulation implementation would be a very formidable tasking.

The cycle consists of these steps: development, execution, analysis & evaluation and improvement. The process must be flexible enough to allow for creative innovation and to assimilate technology as tools are developed and are available.

Skilled Personnel

The second factor in our simulation equation is personnel. The discussion will focus upon the knowledge and skill requirements. The process of designing, building, and using threat simulations is a busy and highly involved set of operations. Due to the number of variables and the differences between threats, design solutions are almost infinite. **Currently no complete training course and no complete user's guide exist.**

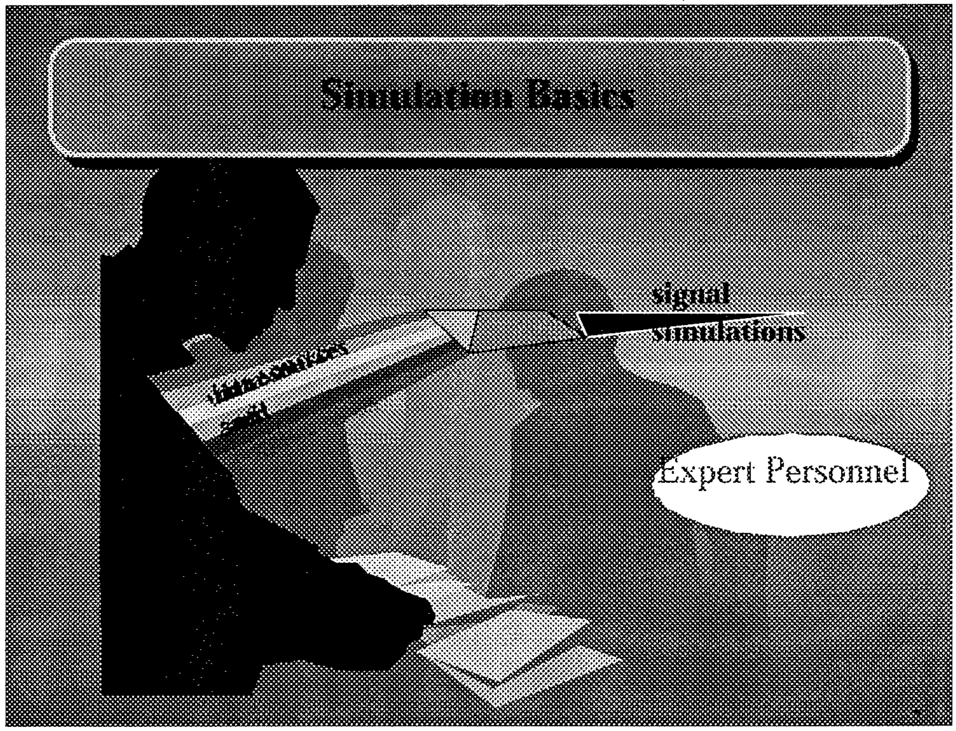


Figure 14

Some of the types of knowledge and skill required are presented in the following figures. Basic understanding of RADAR principles is fundamental. Knowledge of test instruments, of their application and use, and of complex measurement principles is required. Understanding signal acquisition and processing functions of the EW system under test is important. As EW systems evolve into integrated suites, one must understand the total system architecture, the system and subsystem functional capabilities, and points to acquire adequate test data.

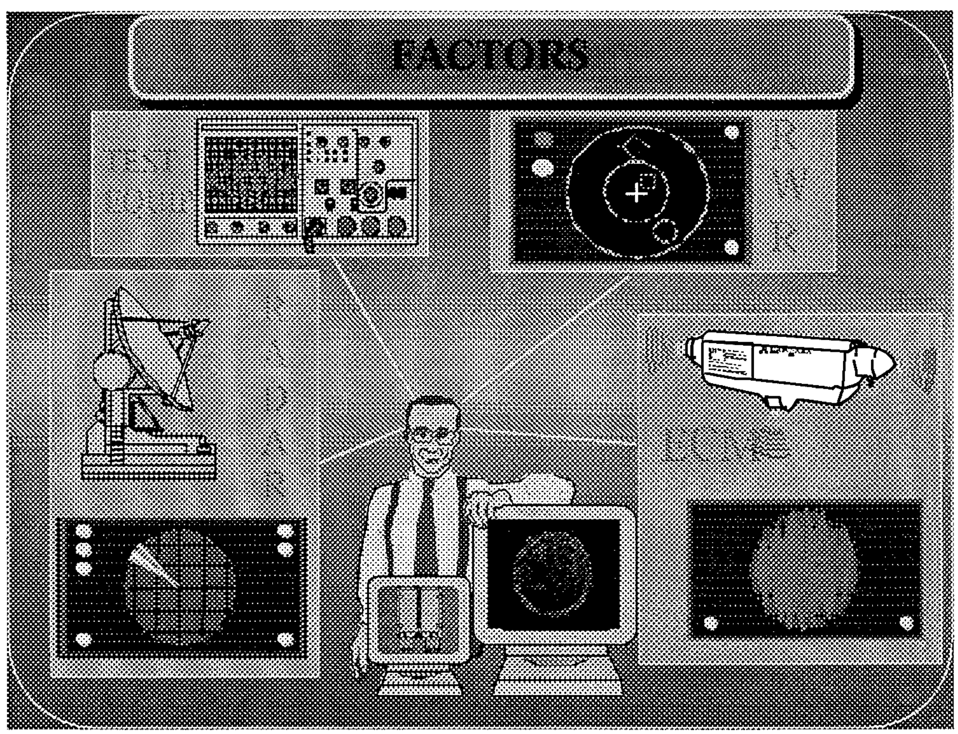


Figure 15

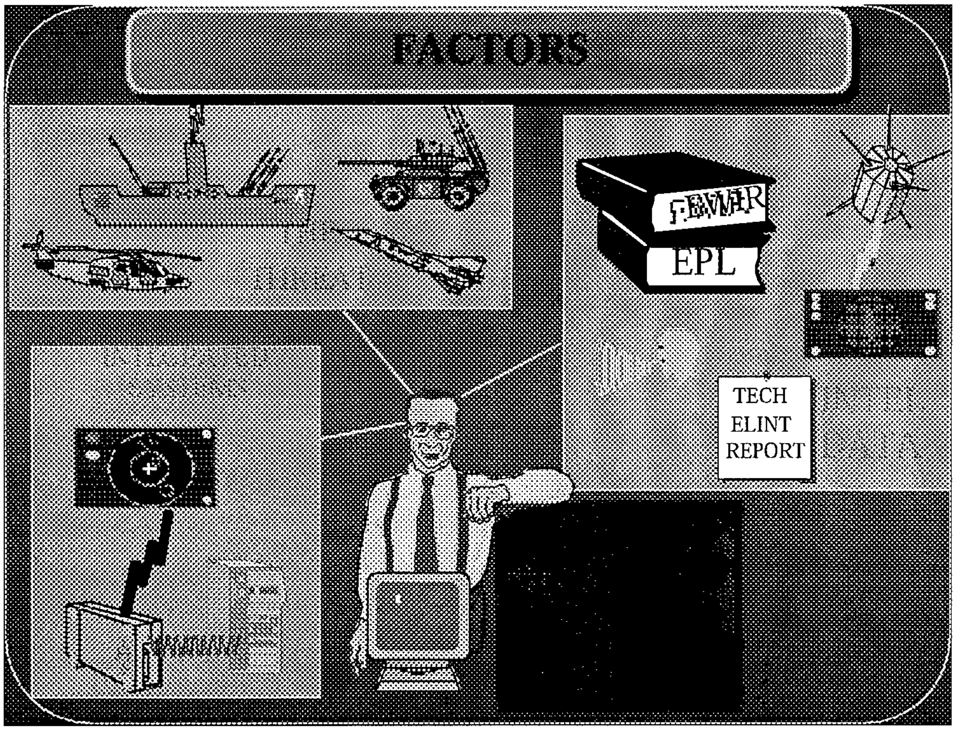


Figure 16

The most critical aspect is to keep current about the threats of interest. Knowledge of threat information databases, their formats, and embedded technical data is necessary in keeping current. Simulation theory and application practice, simulator platform acquisition & sustainment, and simulation software are also very important. The necessary knowledge and skill in our circumstance is distributed among a small team. Similar to the overall success keys, there must be proper balance. Technology can provide assistance in performing simulation operations and in training of personnel but the required technological toolset are not available.

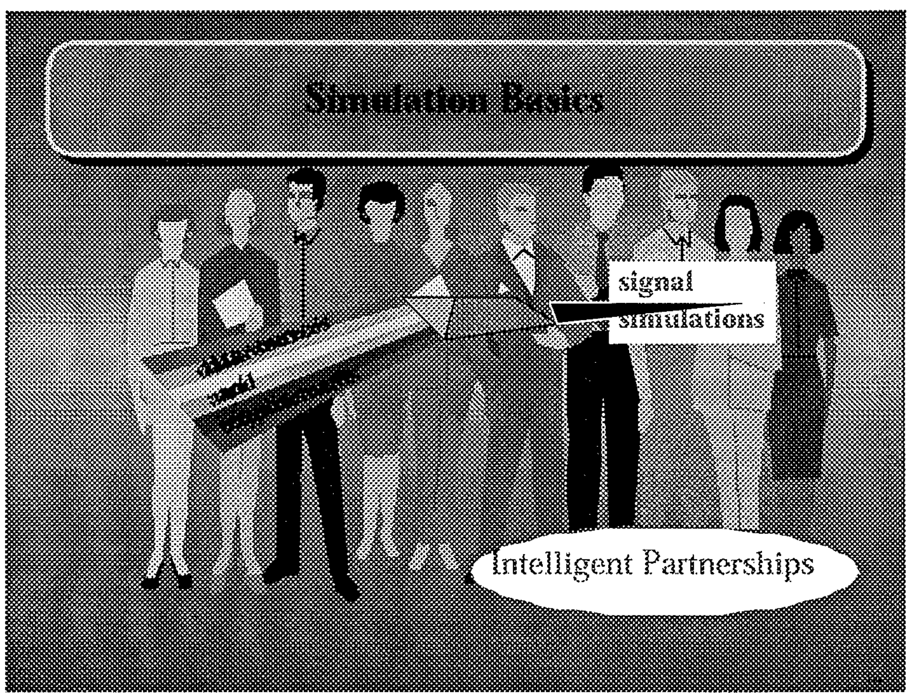


Figure 17

Partnerships

Intelligent partnerships are important. Our partnerships include the following: 1) our **customers** -- the providers of the requirements and of the necessary funding; 2) our **intelligence sources** -- the providers of the necessary threat data; 3) our **logistics and research partners** who provide hardware, software and facilities; 4) our **test**

partners who provide test data and test methodology practices; and 5) our **contractors** who provide technical and materiel support.

4.0 Conclusion

Today there is a challenge within a System Integration Laboratory concerning adequate development and use of simulations. Meeting tomorrow's simulation challenge will still depend upon the these three basic resources in proper balance: 1) expert personnel; 2) intelligent partnerships; and 3) technology and processes. The process and technology are certainly very critical in maintaining excellence; however, we must not fail to realize that although personnel elimination is good for the financial aspect of operations, that the performance edge has come from human effort and expertise.

Acknowledgments

I wish to thank my co-workers and management in the Electronic Warfare Management Directorate, Robins AFB, GA for the opportunity, support and cooperation in providing material and editorial comments. In particular, contributions of Mr. Frank Sasso and Mr. Wayne Williams concerning some of the figures/illustrations. Also, note that the opinions expressed within this paper are of the author and are not necessarily those of the organization.

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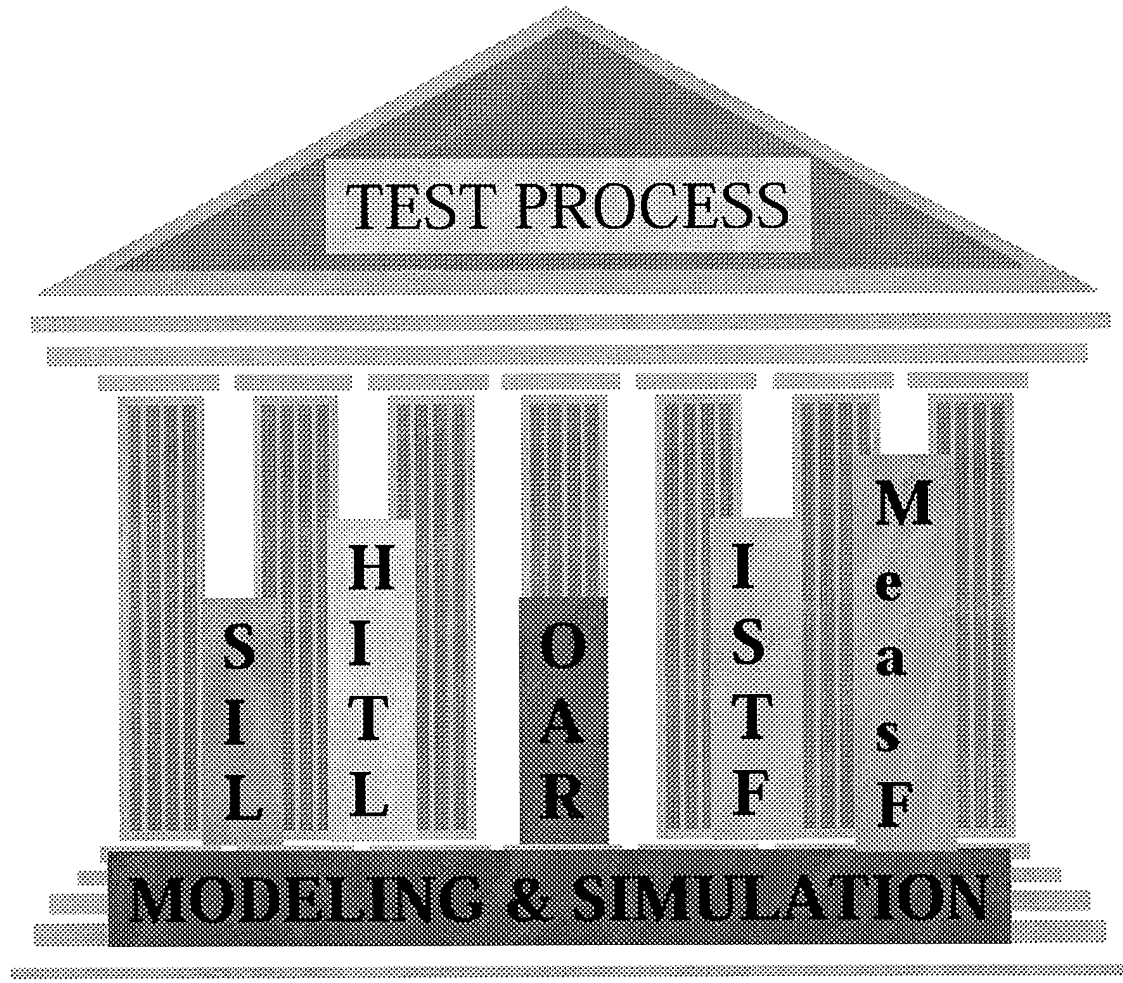
2. E. Jeffrey Conklin and William Weil, "Wicked Problems: Naming the Pain in Organization", 1997, http:// www.gdss.com/wicked.htm.

Modeling & Simulation

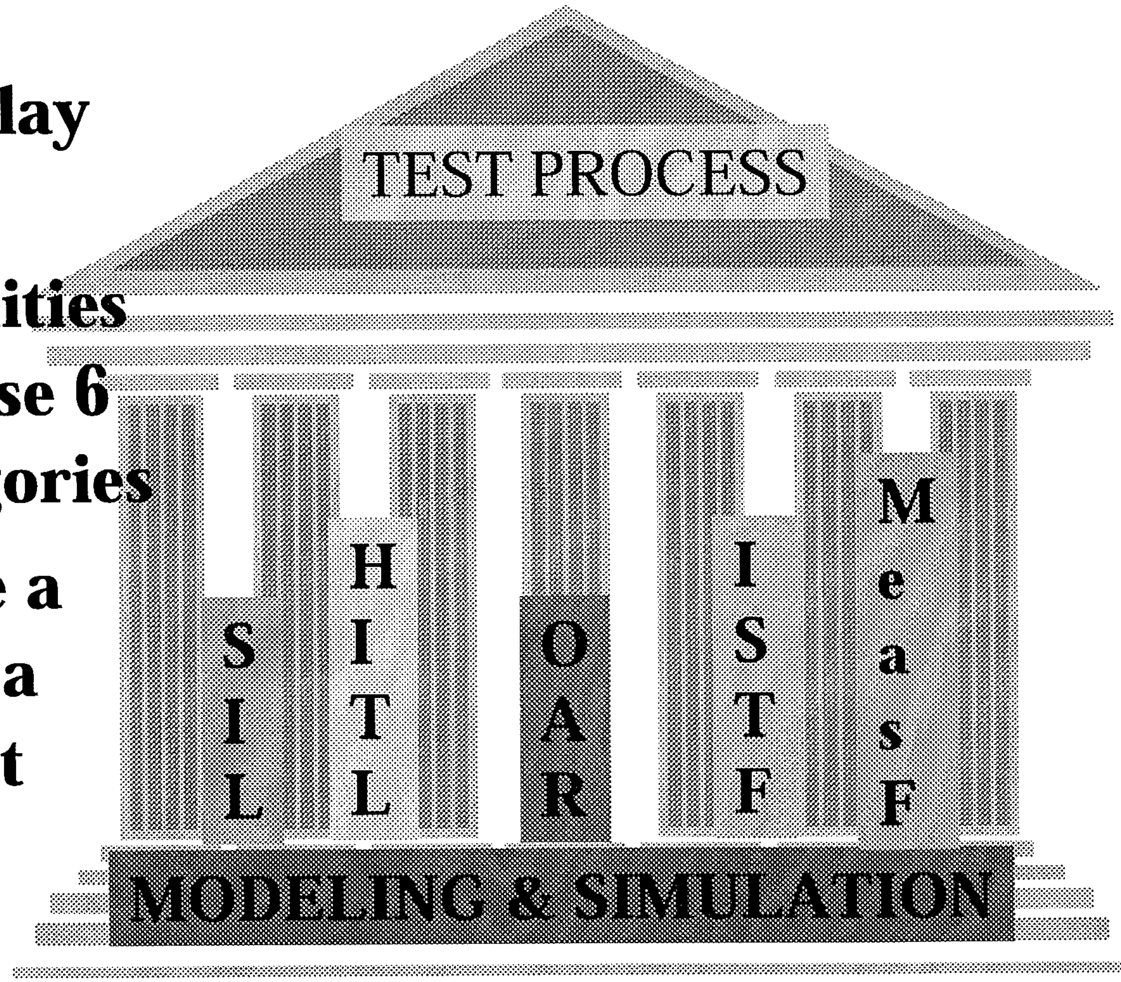
- Overview
- Description
- Role
- Questions



99c

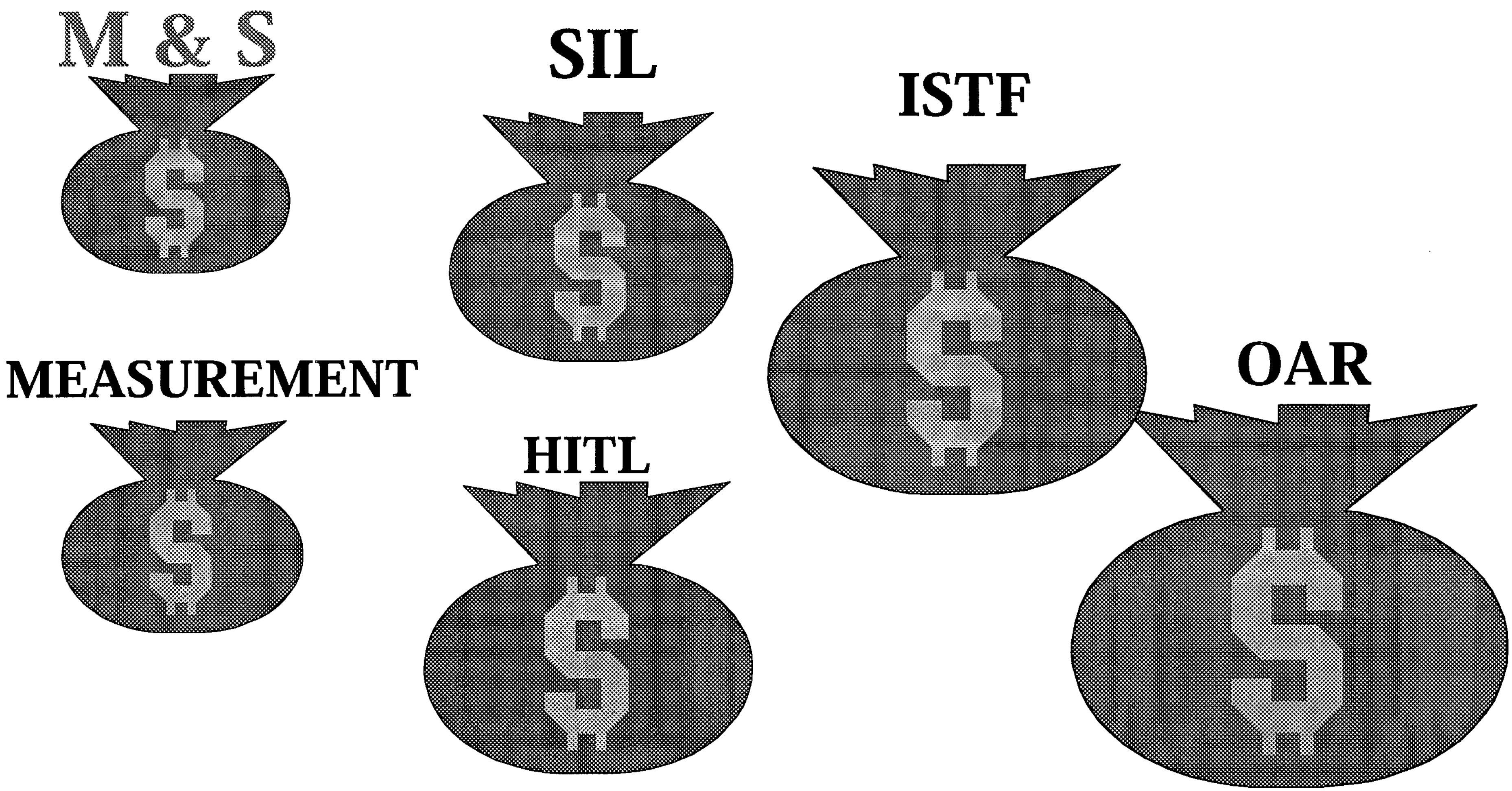
OVERVIEW

- all have role to play
- variations exist between the facilities grouped into these 6 test facility categories
- each can provide a rigorous test for a system under test



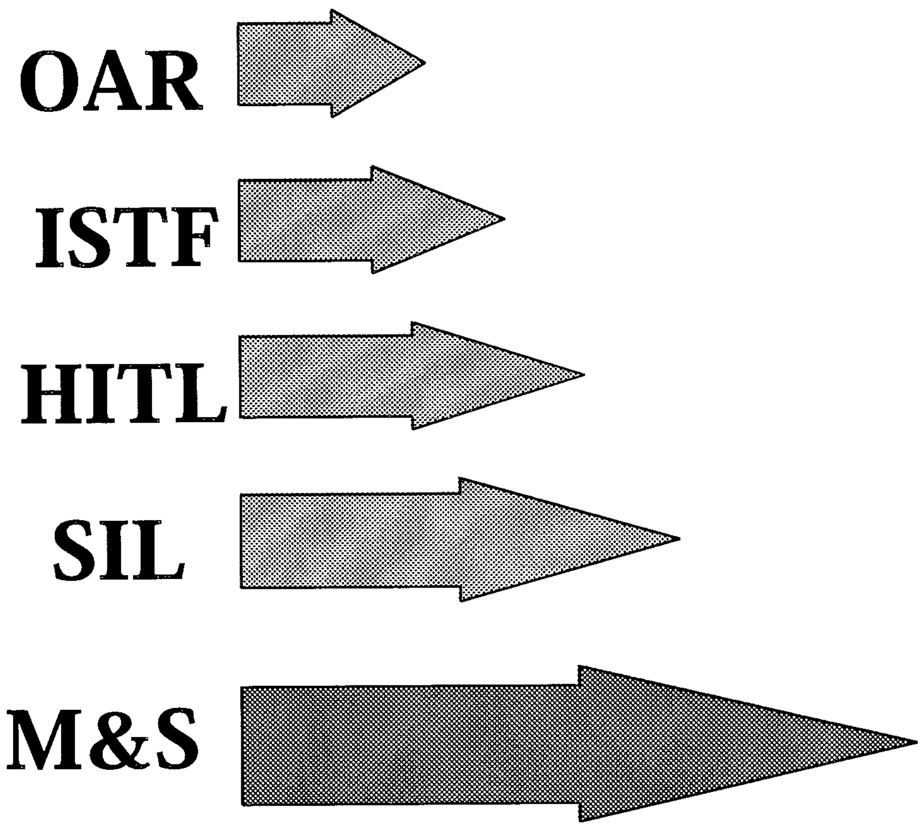
JAWSpanel-2

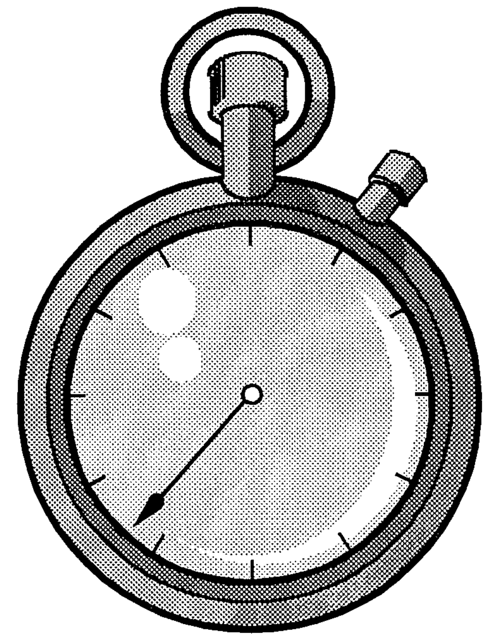
OVERVIEW-- Relative Cost Utilization



JAWS panel-3

OVERVIEW-- TEST TRIALS vs TIME

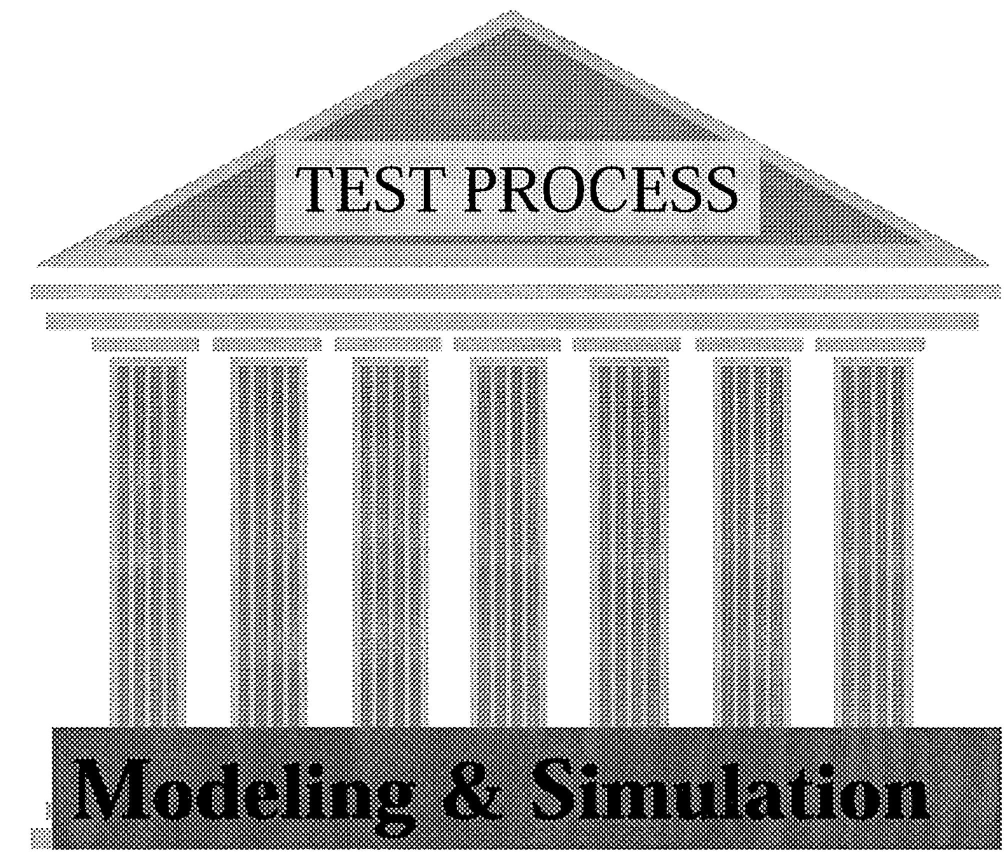




MEASUREMENT **Not applicable**

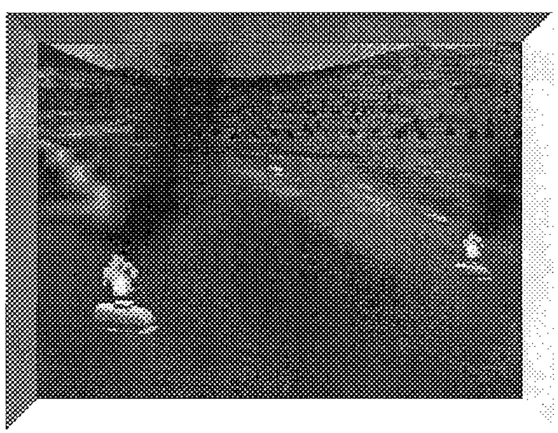
OVERVIEW

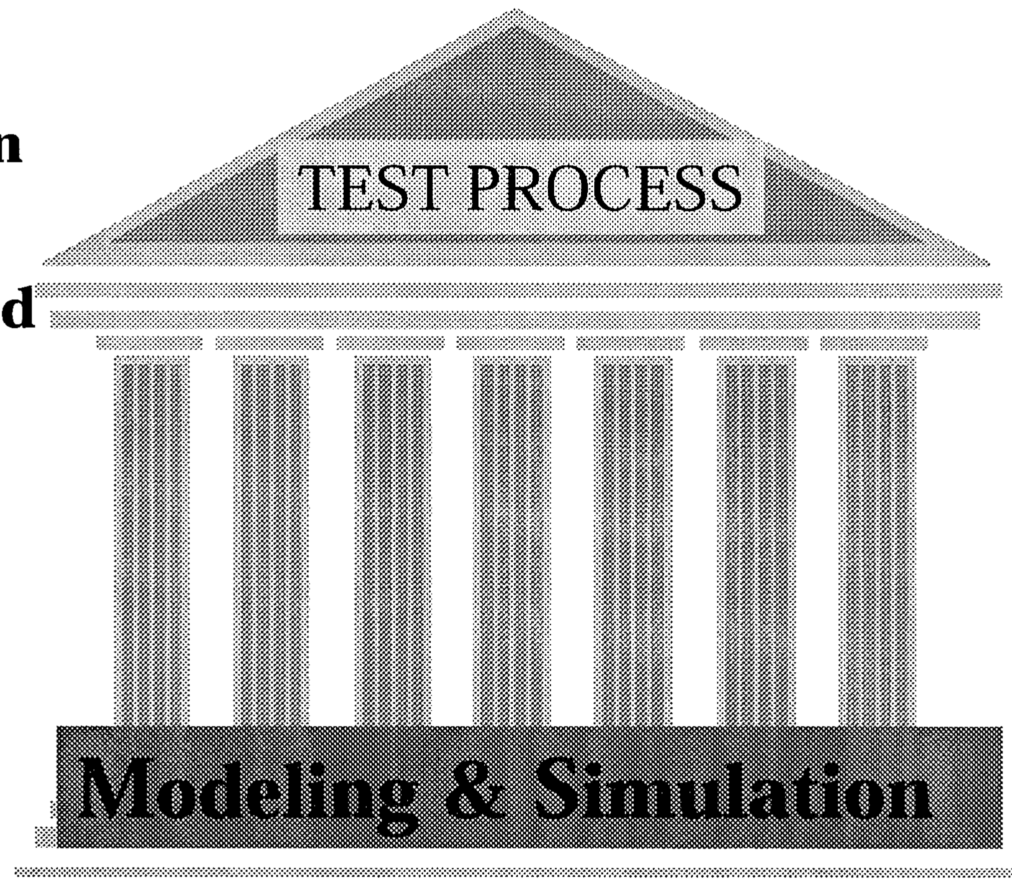
- Definition
- Significance
- "The issue is no longer whether extensive use of modeling and simulation tools has merit, but rather how to develop and apply a new acquisition process ... Dr. Patricia Sanders OSD/DTSE&E



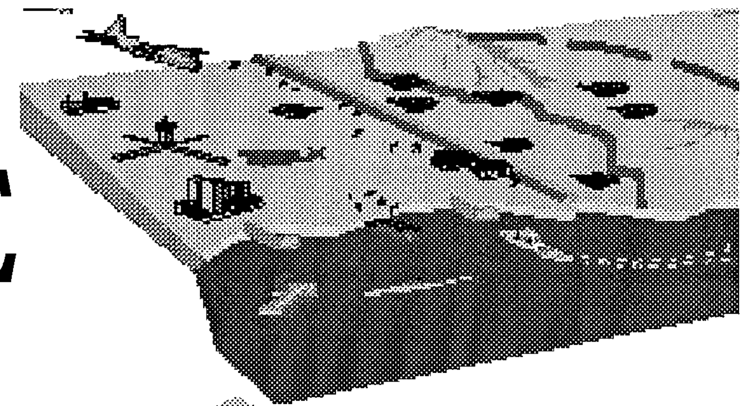
DESCRIPTION

- "simple" to complex
- engineering to campaign levels
- limited to total simulated
- real and simulated interactive



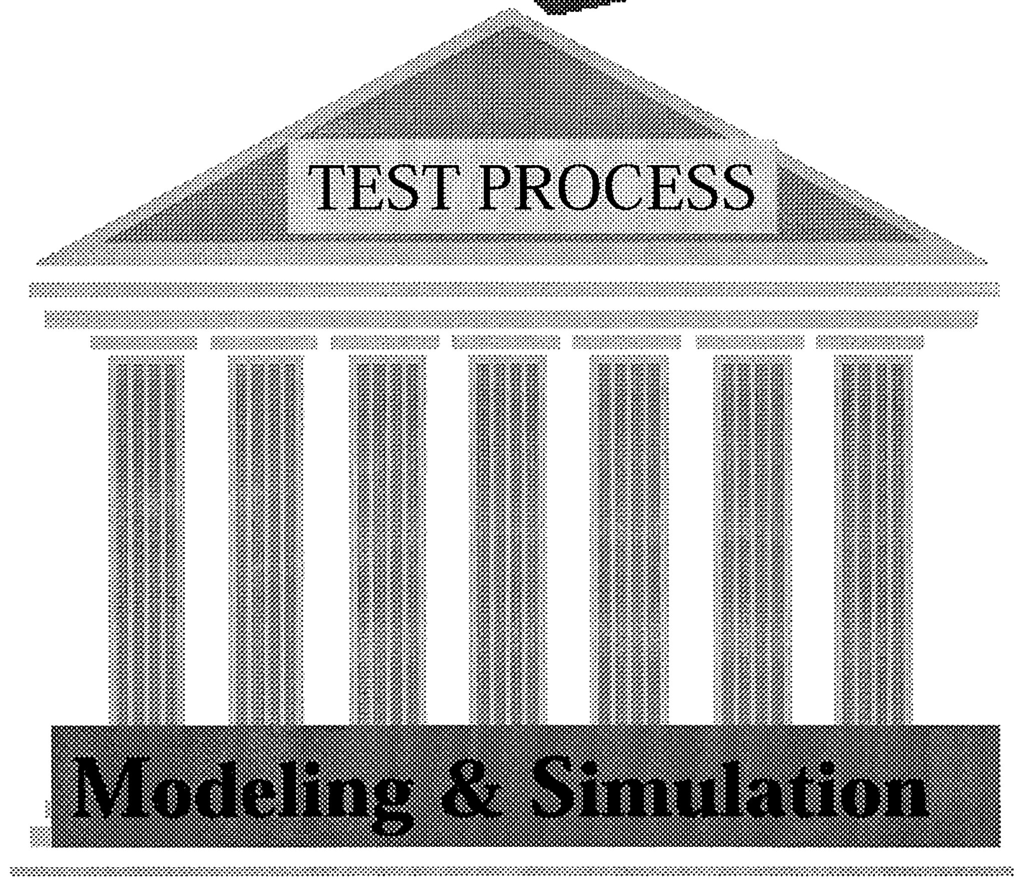


ROLE



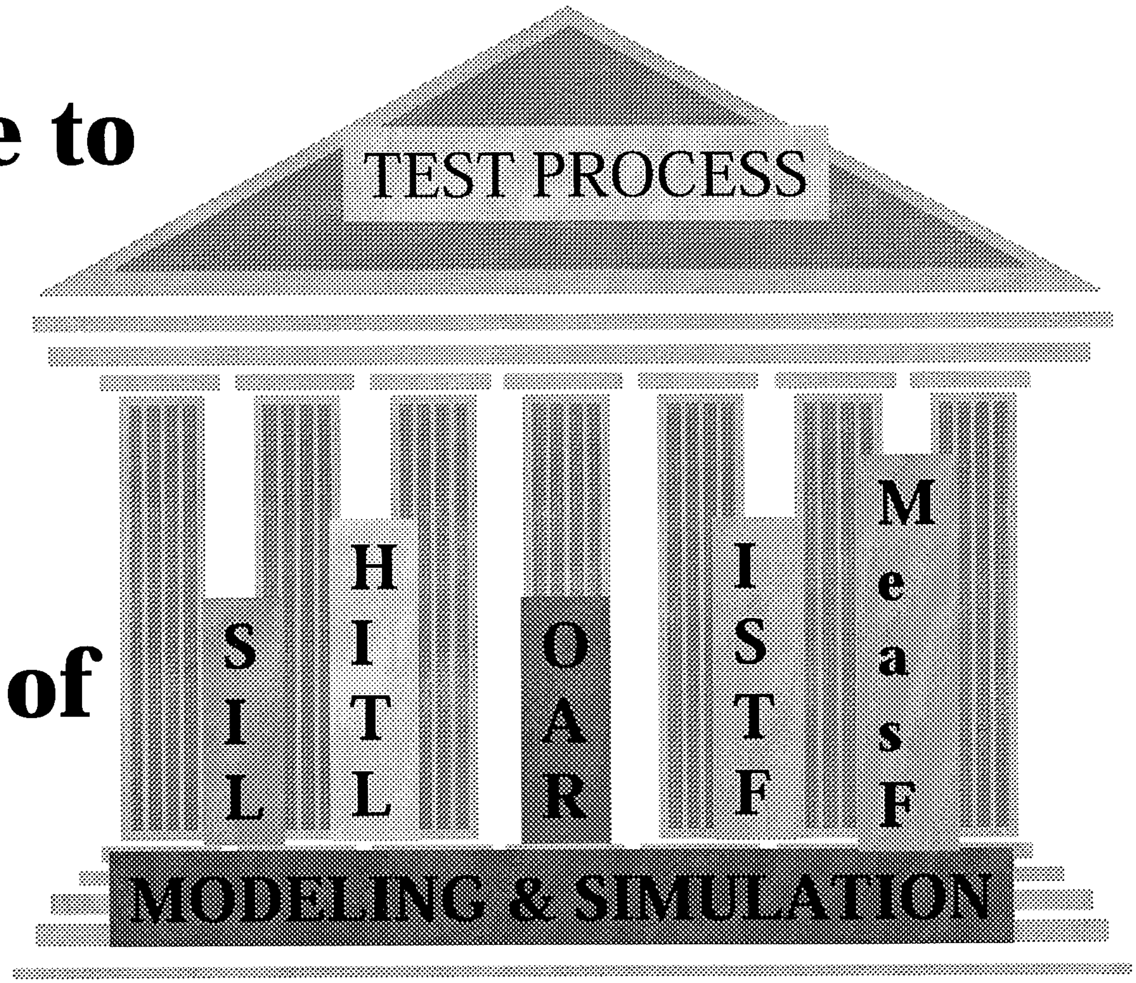
- **Beginning to End**
- **Acquisition support**
- **Testing & Training**
- **"Modeling and Simulation will allow us to make better decisions, develop better warfighting skills, and demonstrate space and air power's contribution to our national defense"**

  Col Jimmy Wilson
  AFAMS



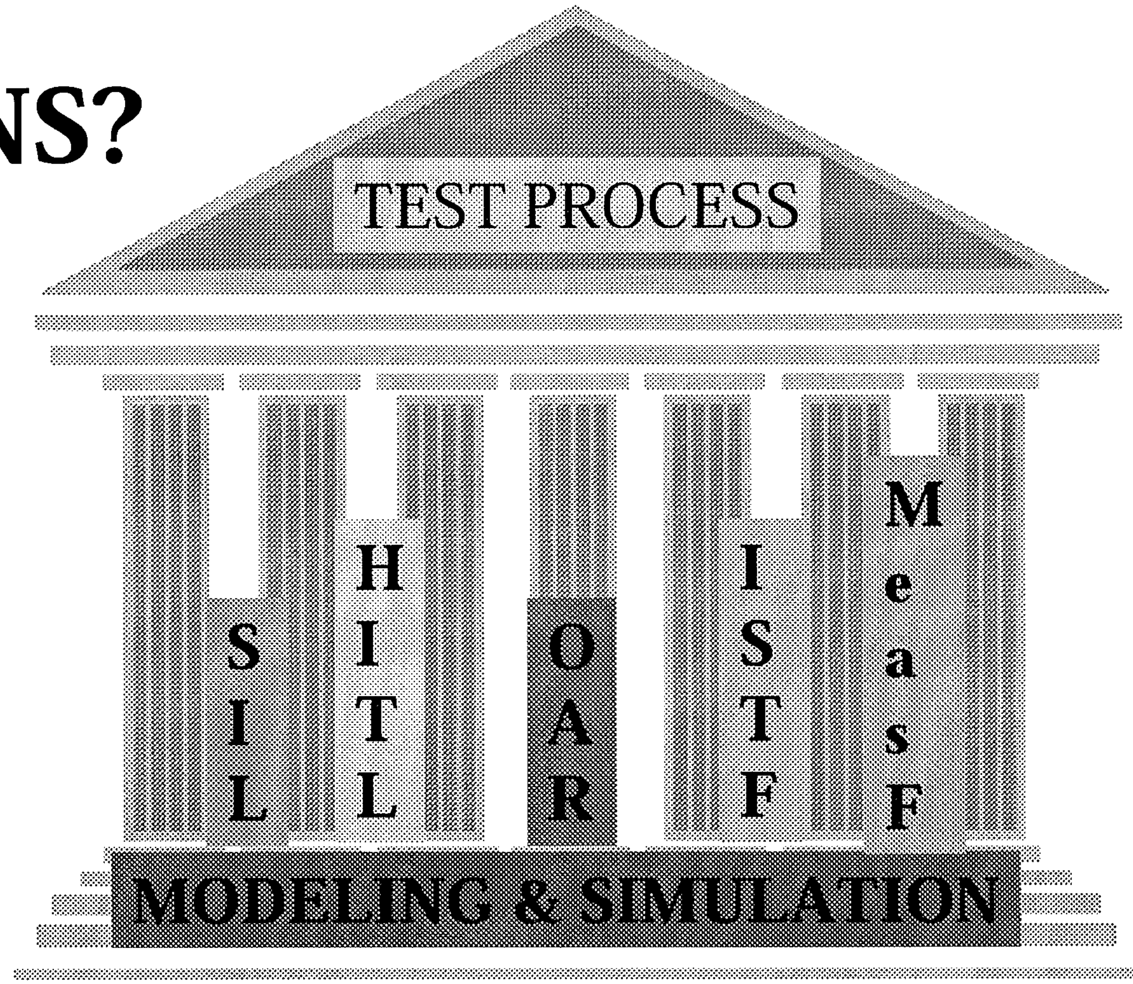
SUMMARY

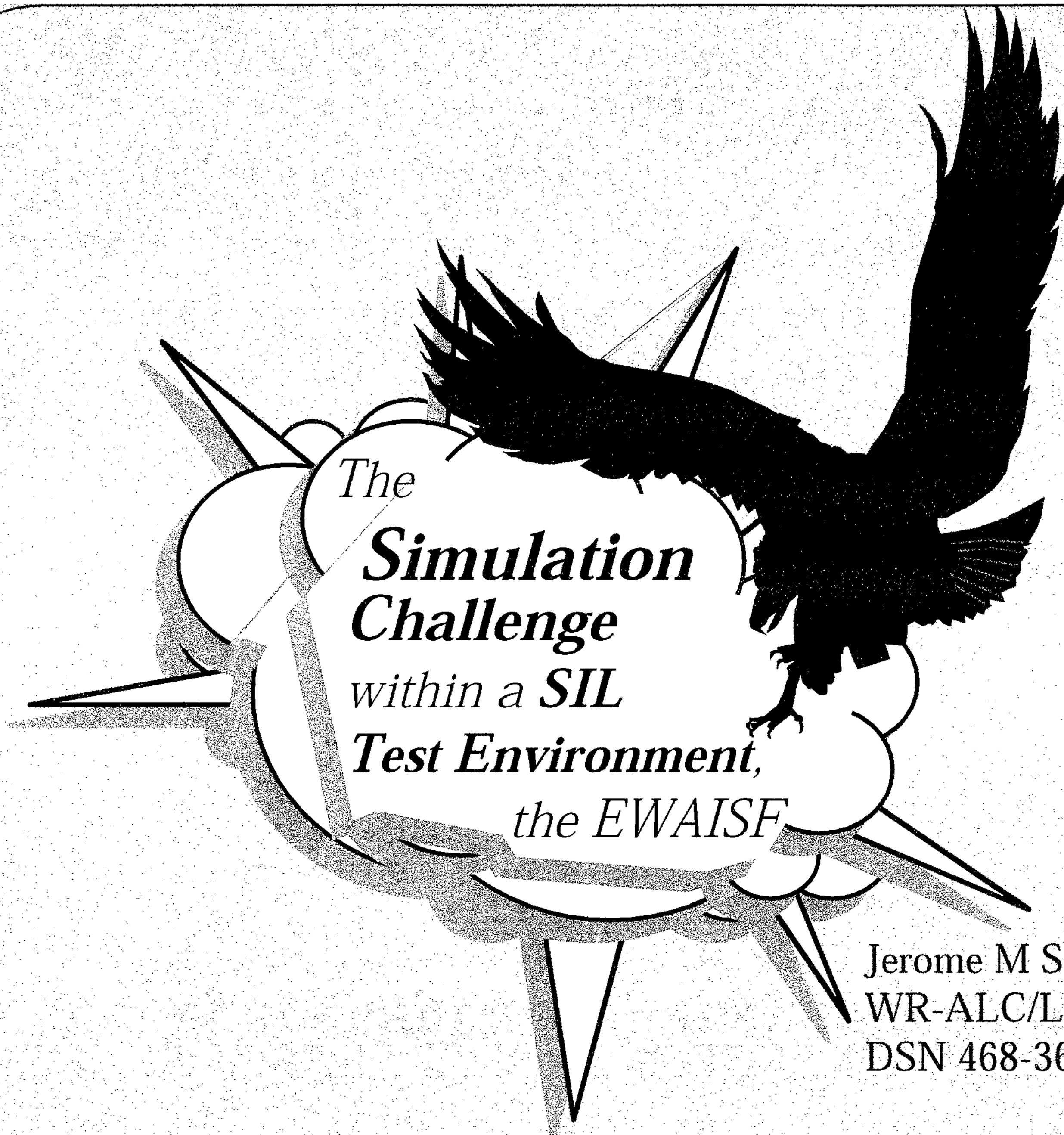
- all have role to play
- all are necessary
- all are part of JAWS,S3



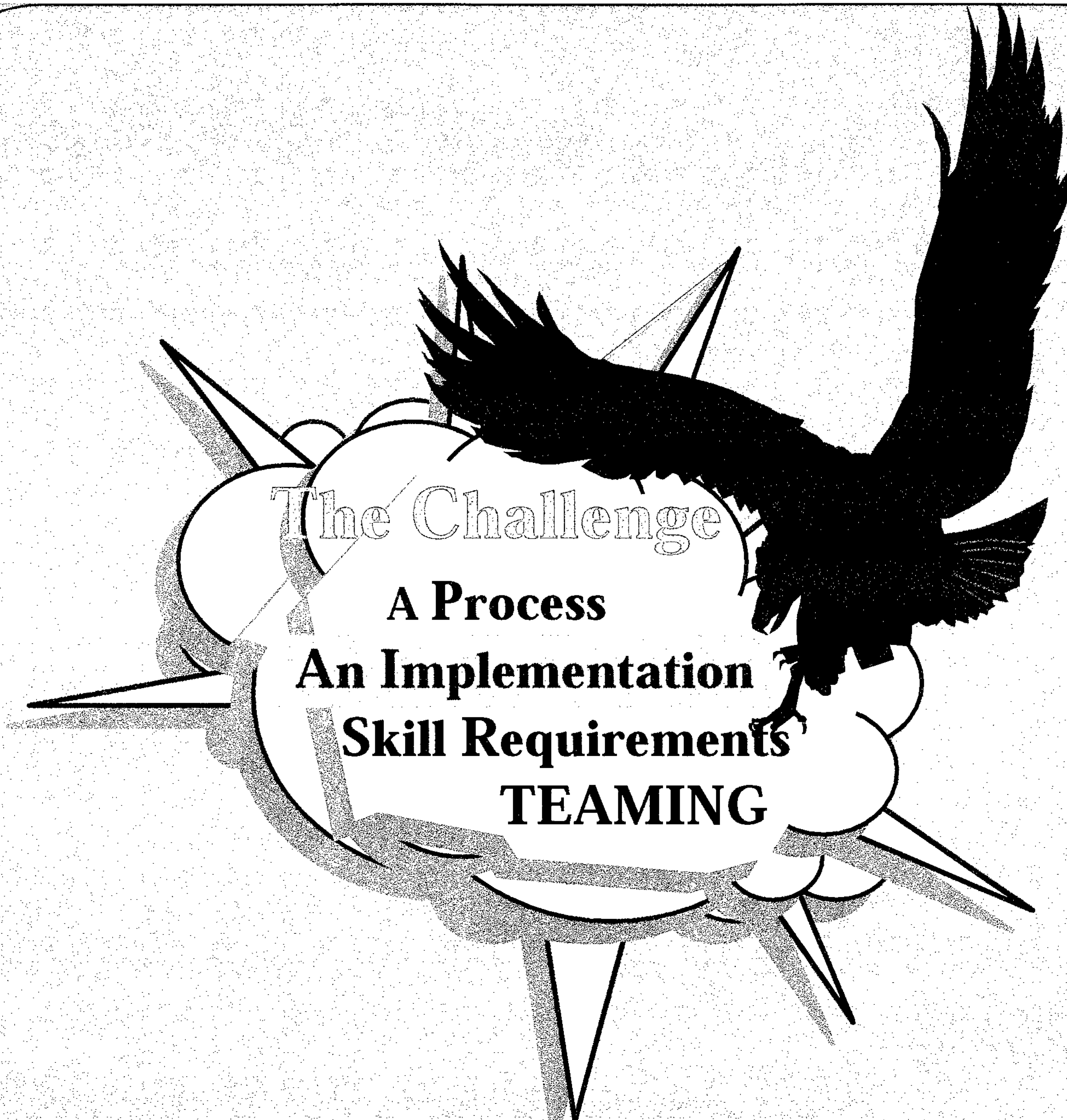
Modeling & Simulation

- QUESTIONS?





Jerome M Smith
WR-ALC/LNEV
DSN 468-3691

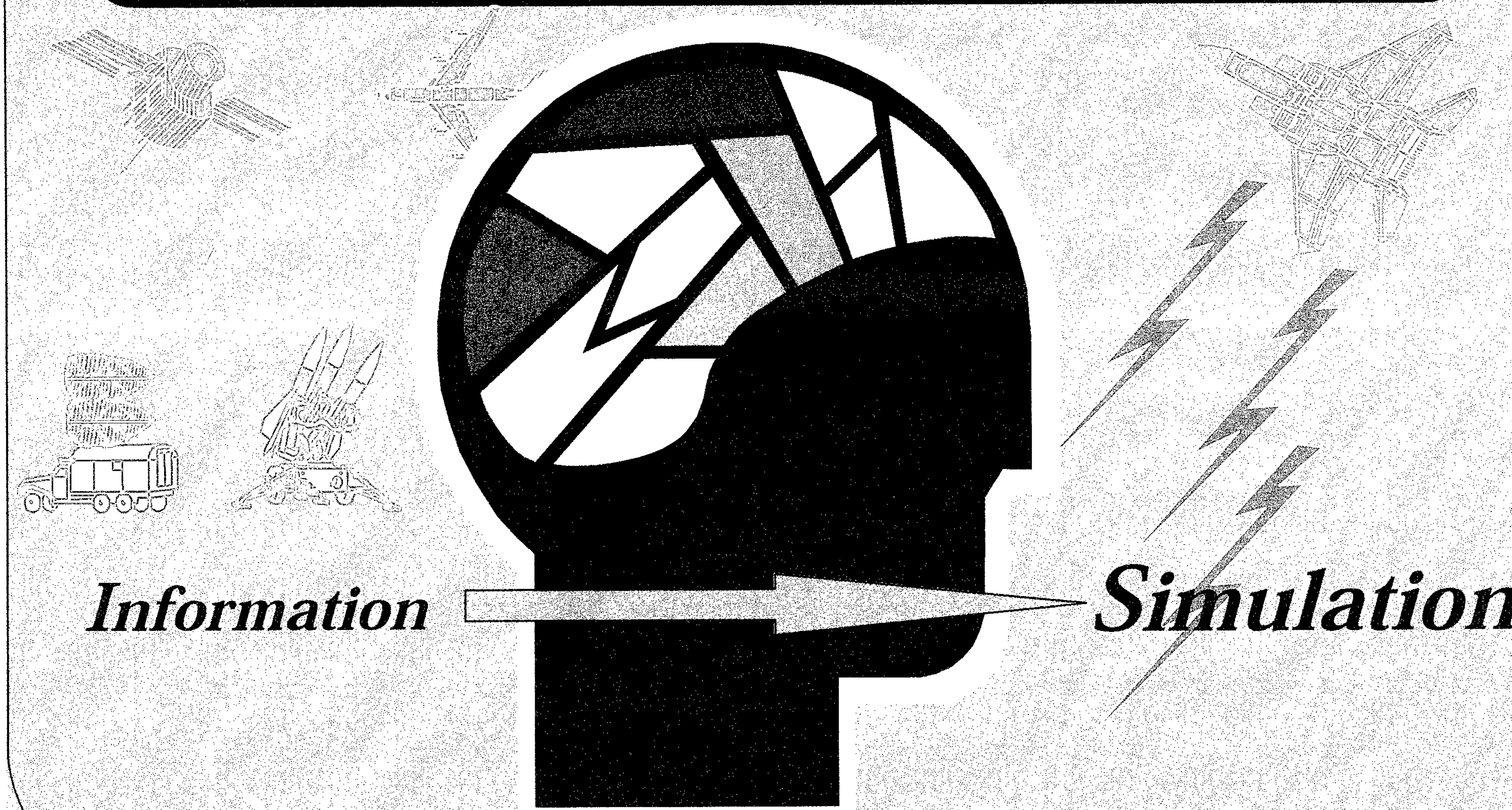

The Challenge
A Process
An Implementation
Skill Requirements
TEAMING

The SIMULATION *CHALLENGE*

- the challenge
- a process of handling the challenge
- technology employed or needed
- process-people-technology relationship

LNEV-3

The Challenge



The CHALLENGE

- not unique to System Integration Labs (SILs)
- three aspects:

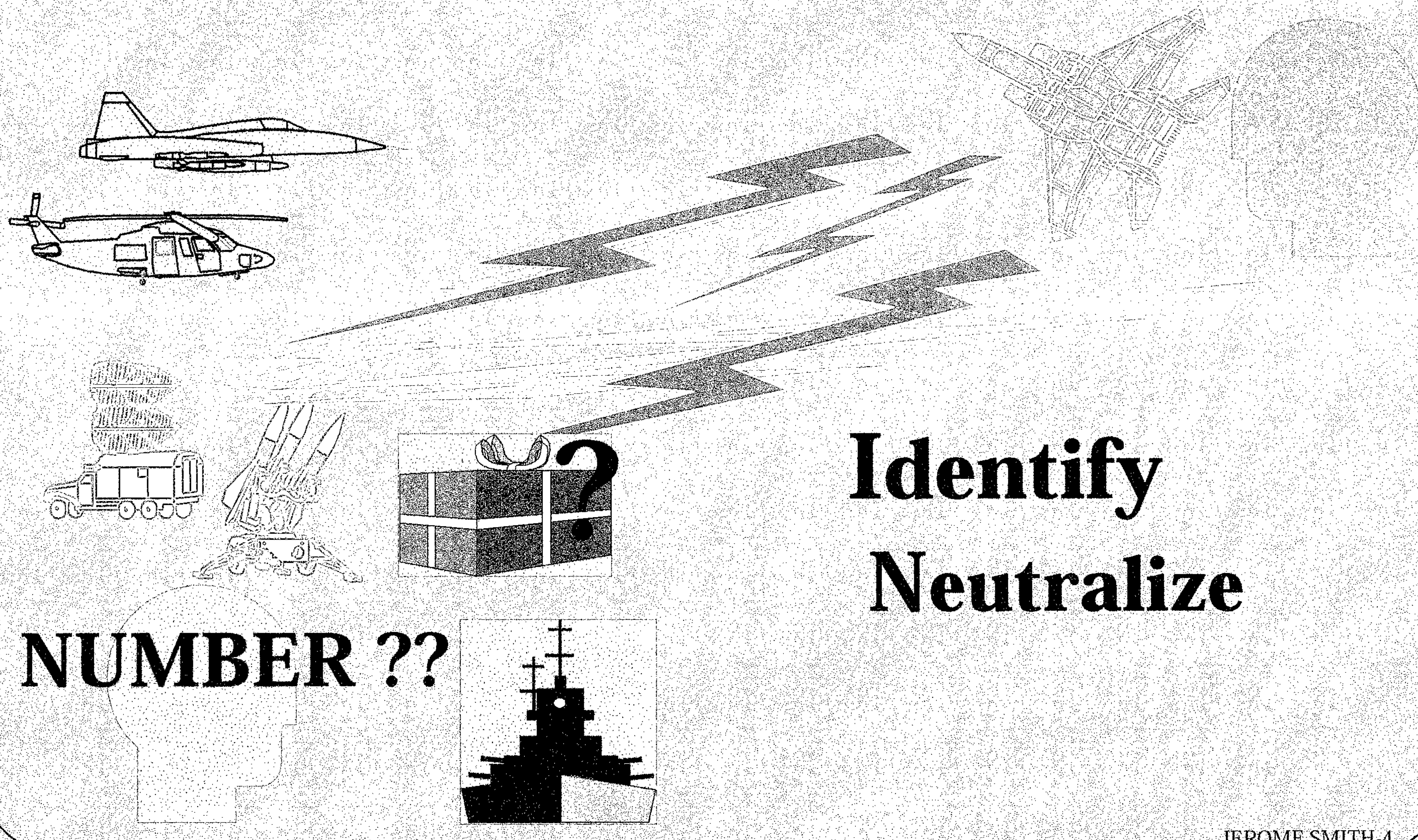
  1) acquisition of information

  2) implementation of process

  3) retention & dissemination
- Adequate simulation is highly sought after

LNEV-5

ELECTRONIC WARFARE



Identify

Neutralize

NUMBER ??

JEROME SMITH-4

LNEV-6

COMPONENTS OF SIMULATION

RADIO FREQUENCY

SECTOR

SCAN

SEARCH

PRI

STAGGER

ERP

TRACK

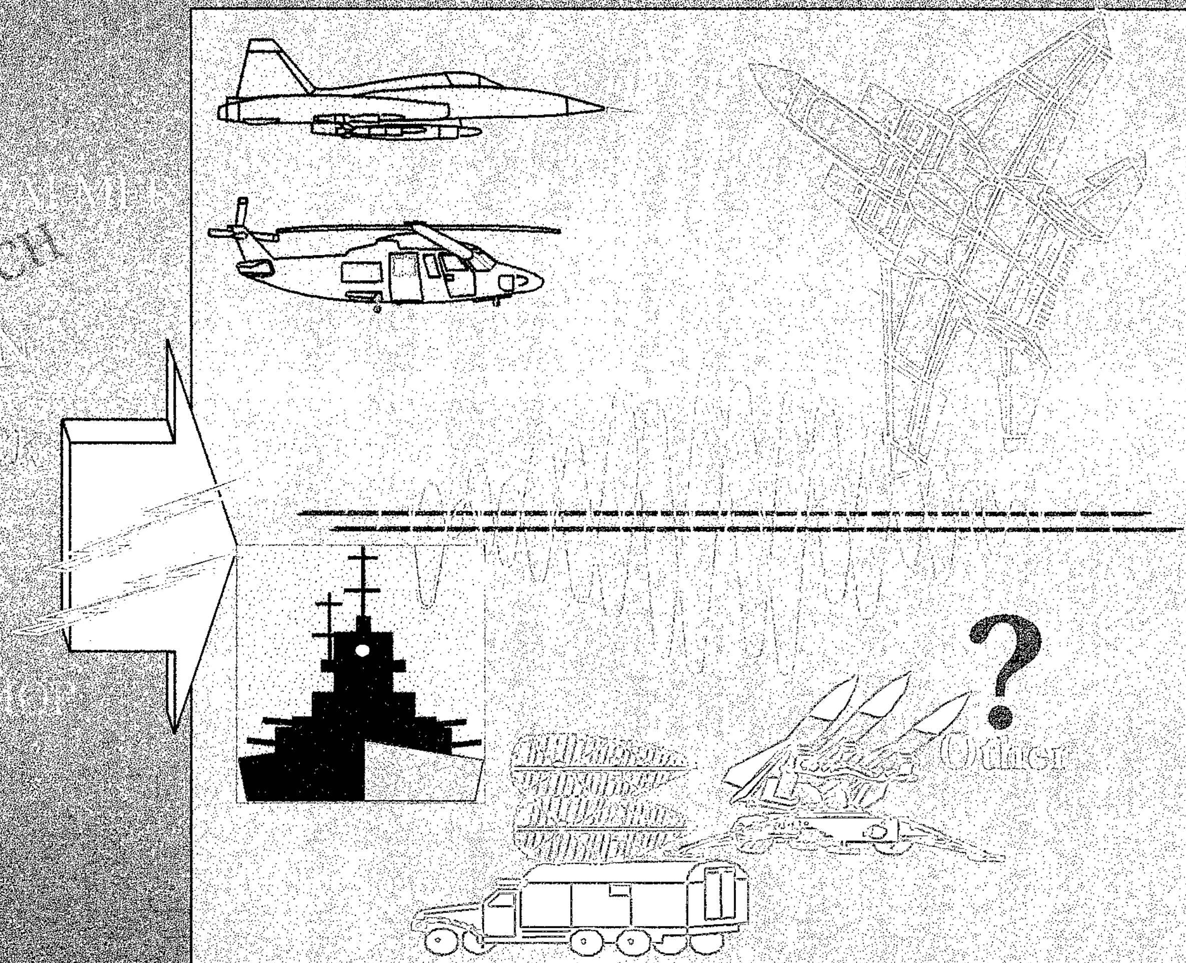
PULSE DOPPLER

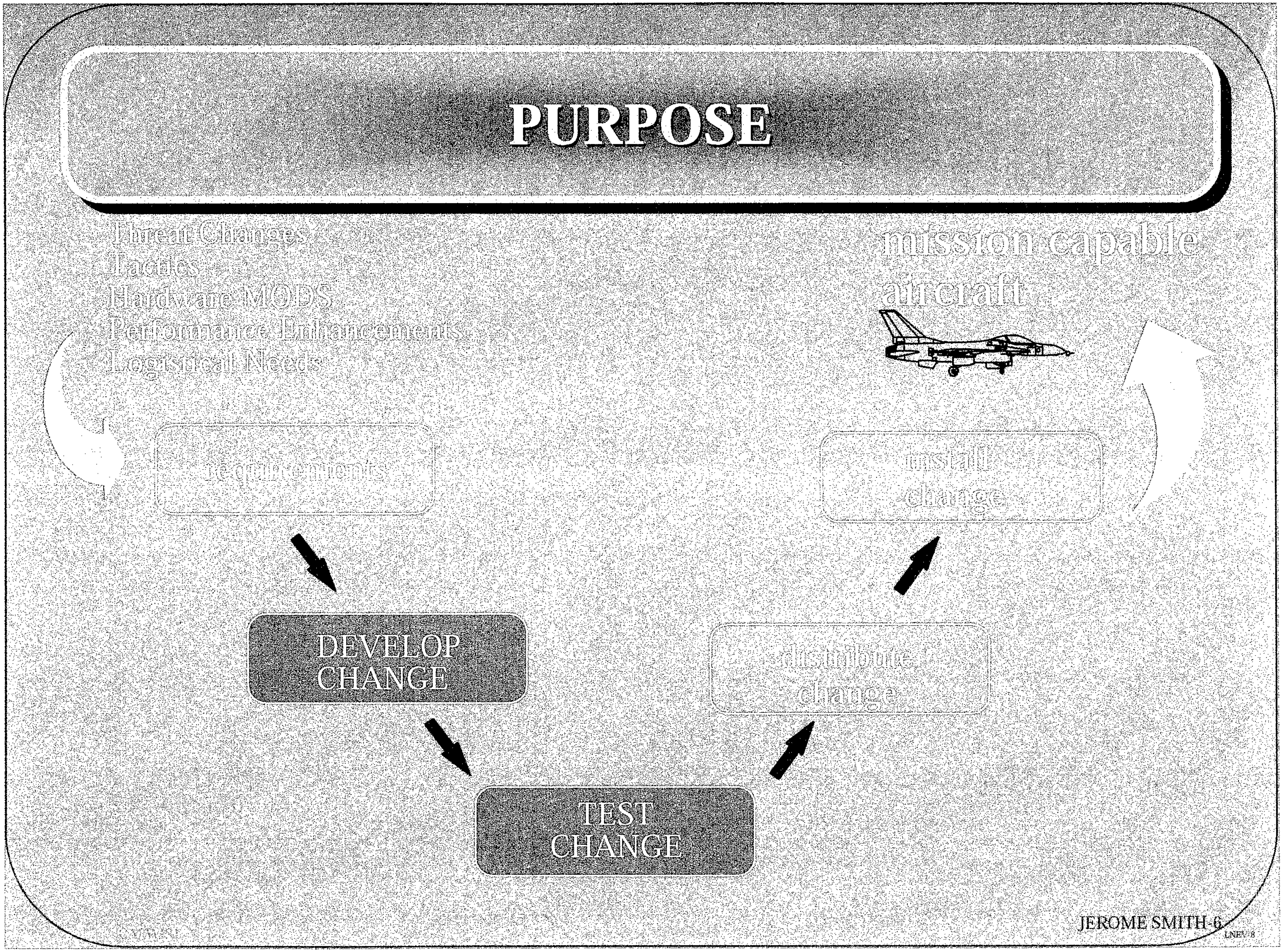
JITTER

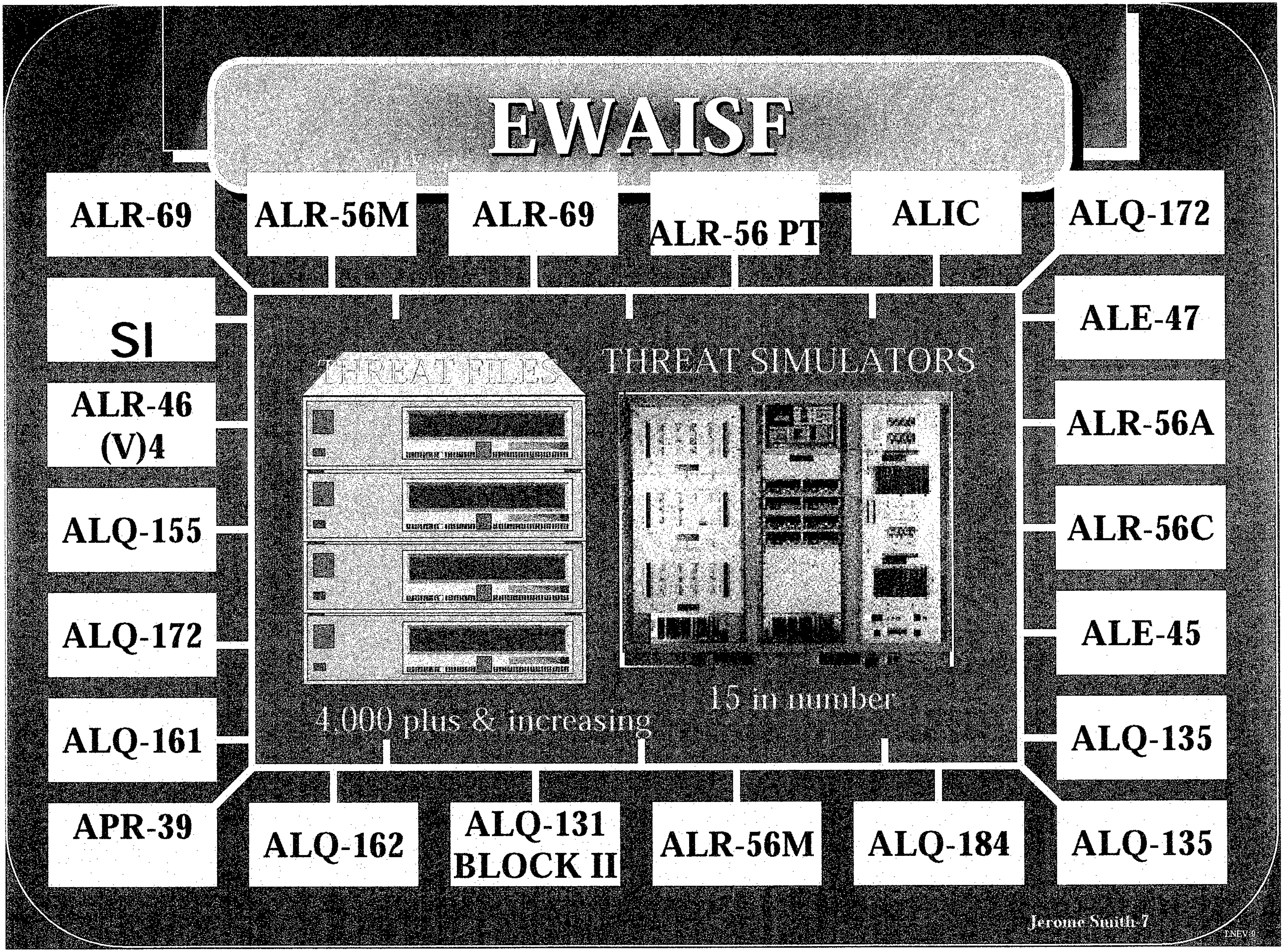
CHIRP

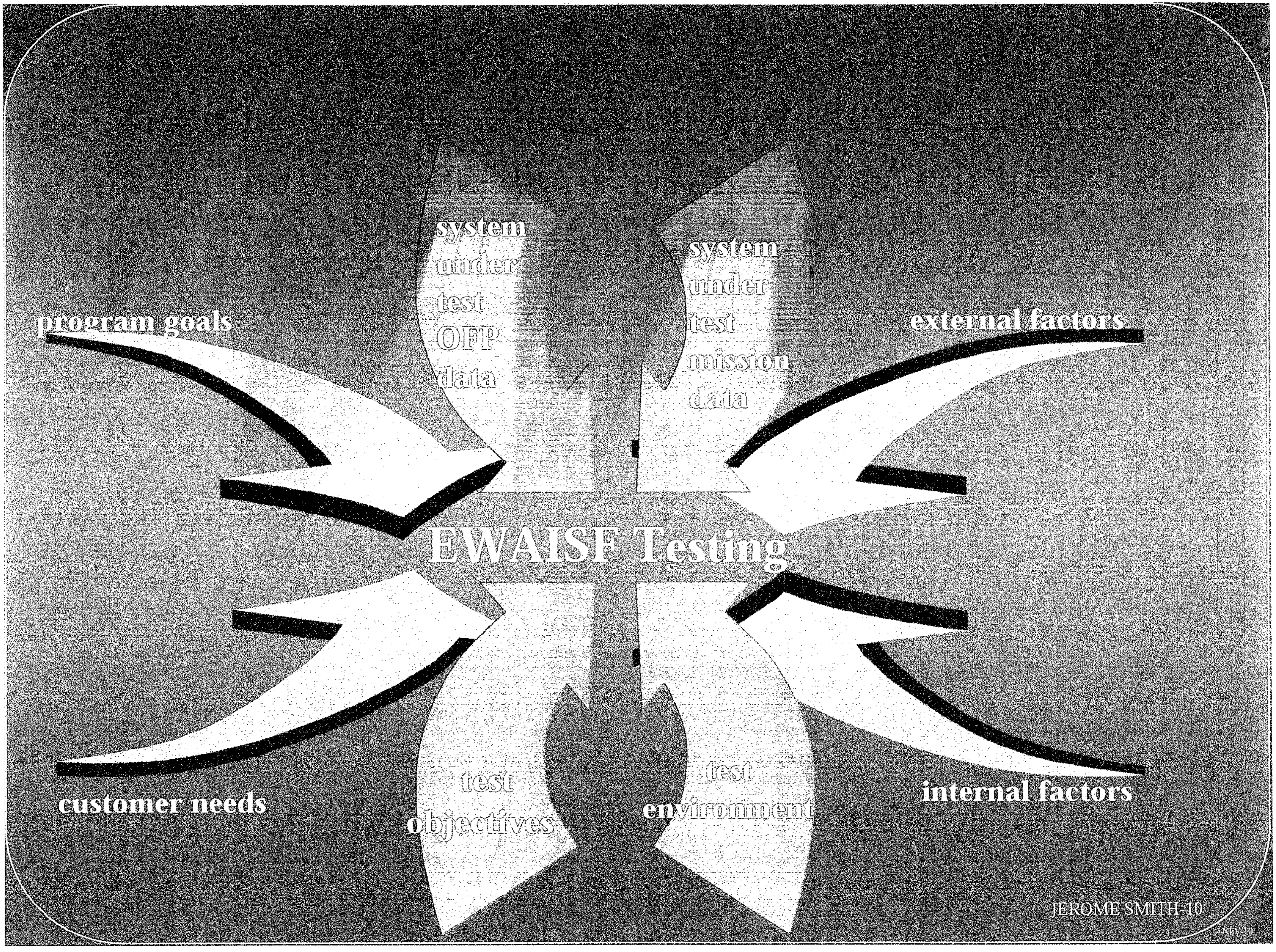
PULSE WIDTH

AGILE

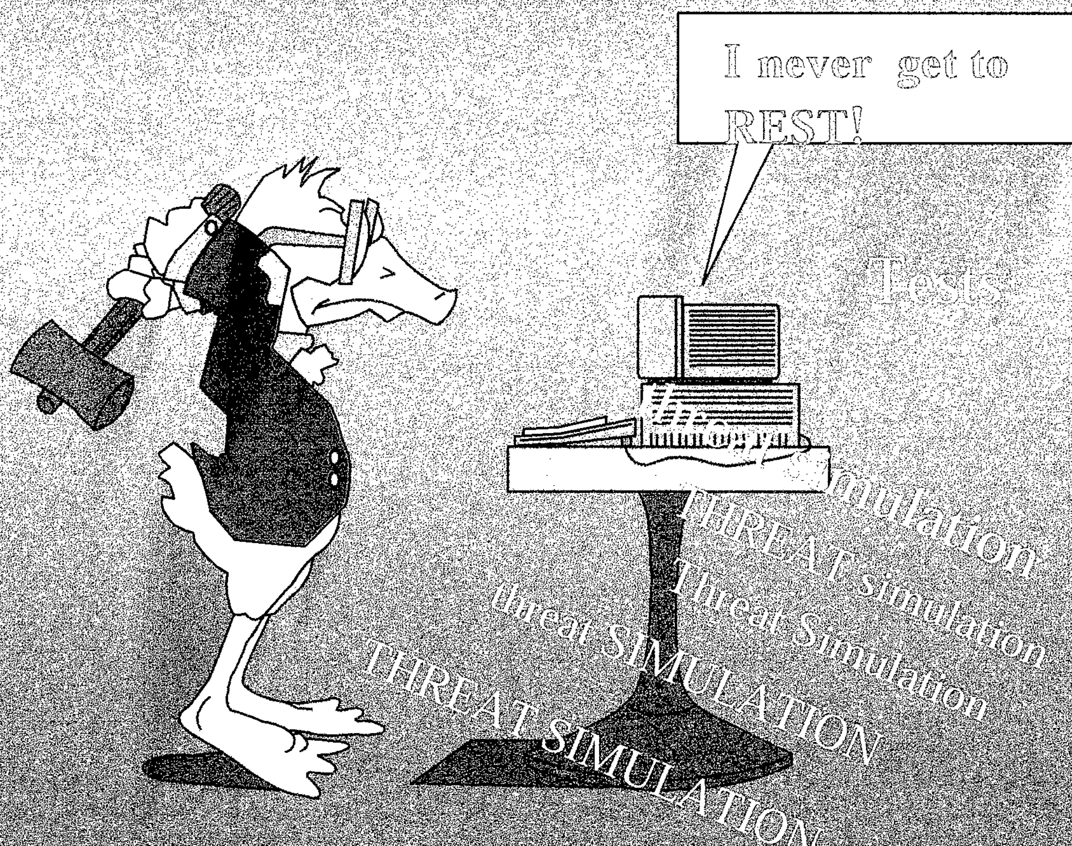



PURPOSE
Threat Changes
Tactics
Hardware MODS
Performance Enhancements
Logistical Needs
requirements
DEVELOP CHANGE
TEST CHANGE
distribute change
install change
mission capable aircraft
JEROME SMITH-6


EWAISF
ALR-69
ALR-56M
ALR-69
ALR-56 PT
ALIC
ALQ-172
SI
ALE-47
ALR-46 (V)4
ALR-56A
ALQ-155
ALR-56C
ALQ-172
ALE-45
ALQ-161
ALQ-135
APR-39
ALQ-162
ALQ-131 BLOCK II
ALR-56M
ALQ-184
ALQ-135
THREAT FILES
4,000 plus & increasing
THREAT SIMULATORS
15 in number
Jerome Smith-7

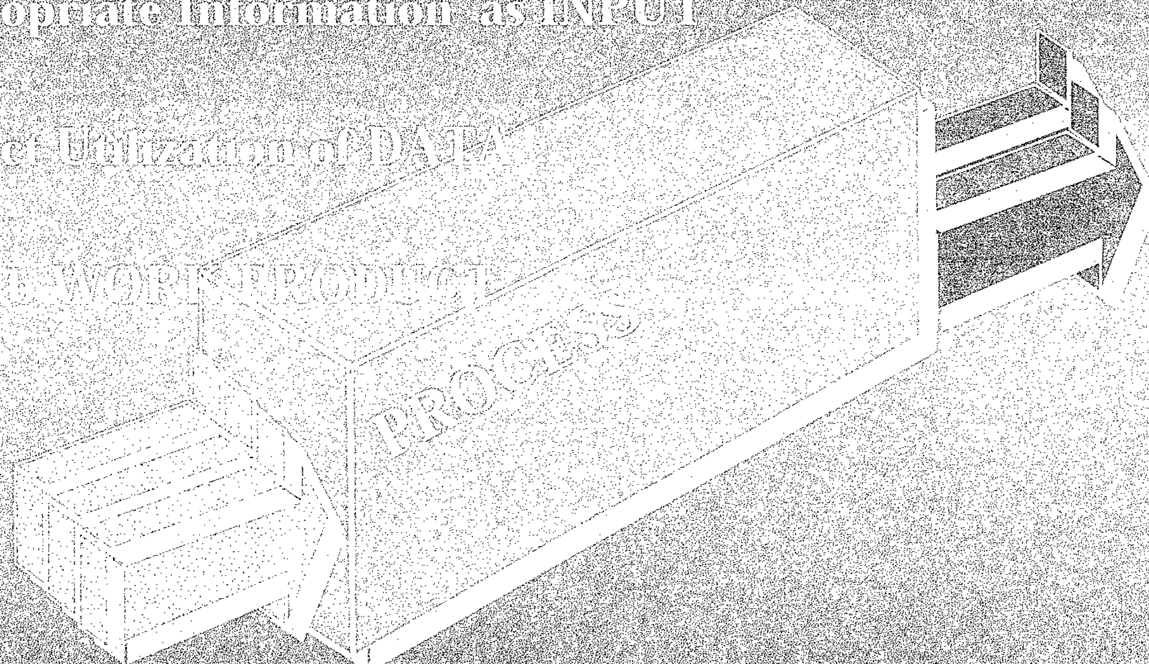

EWAISF Testing
program goals
customer needs
external factors
internal factors
system under test OFP data
system under test mission data
test objectives
test environment
JEROME SMITH-10

Simulation, our Process

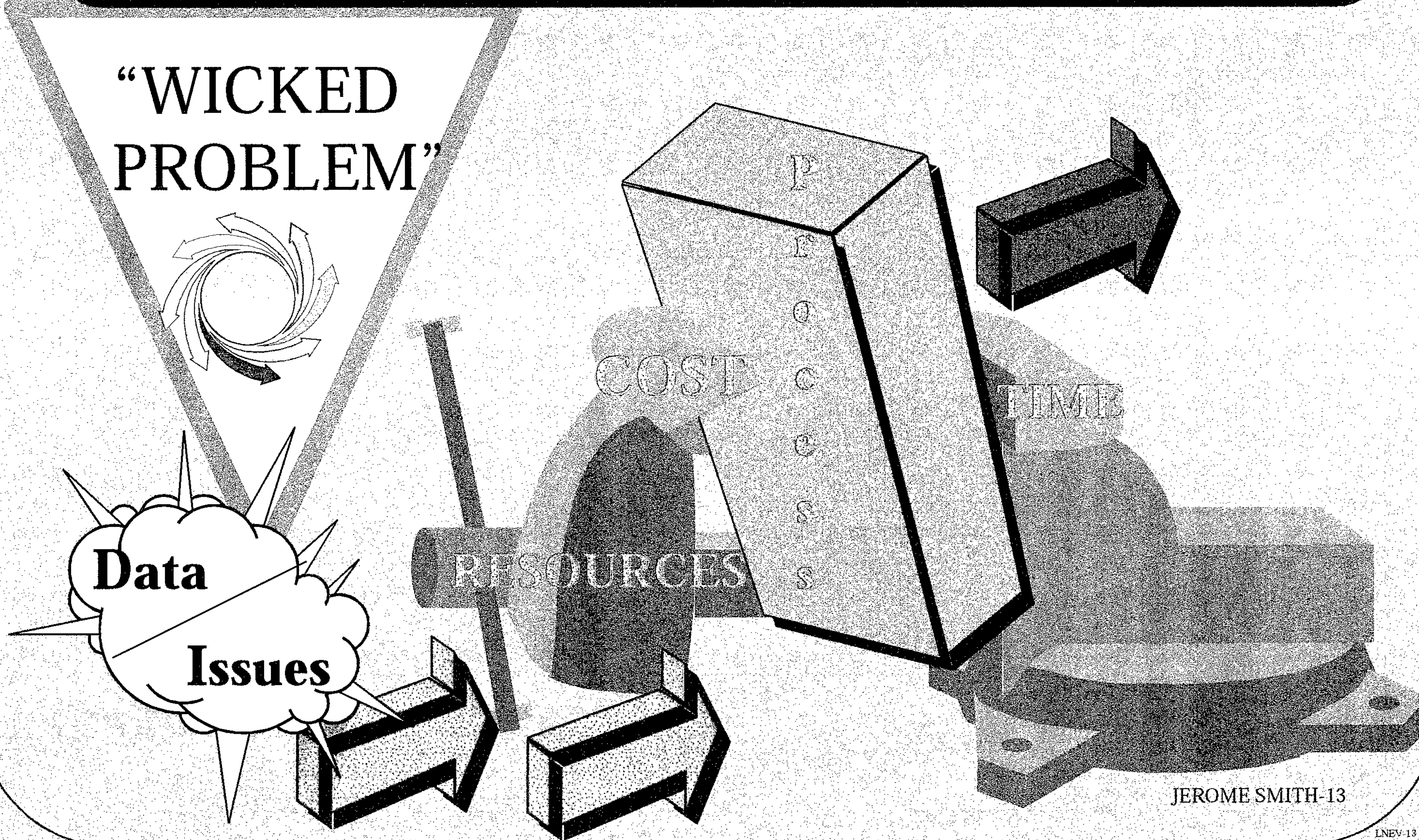


The IDEAL

- Appropriate Information as INPUT
- Perfect Utilization of DATA
- Elite WORK PRODUCT



OUR REALITY



JEROME SMITH-13

LNEV-13

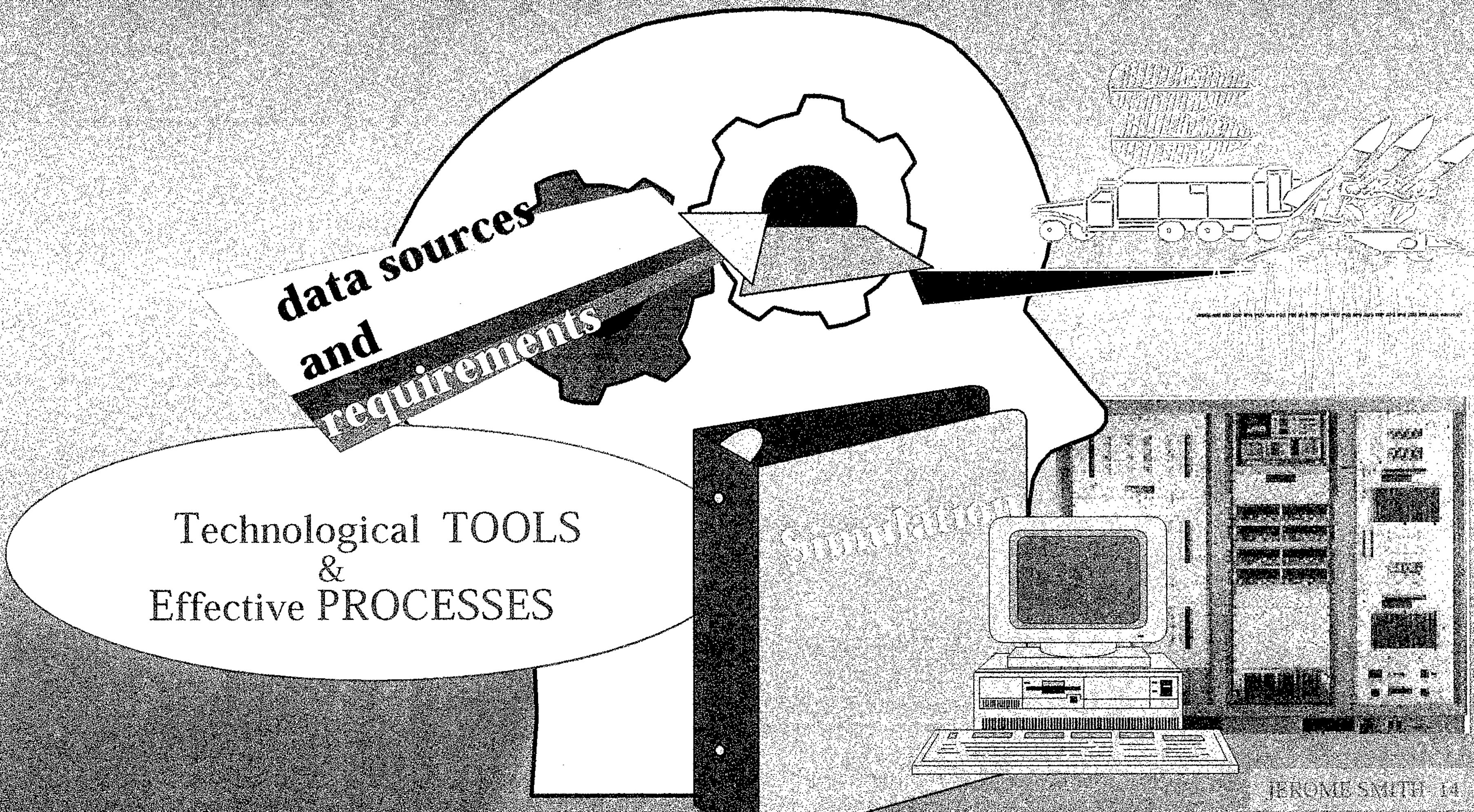
IDEAL versus Reality

- complete information & requirements
- perfect management, manipulation & use
- right quantity, absolute technical accuracy, and perfect utility

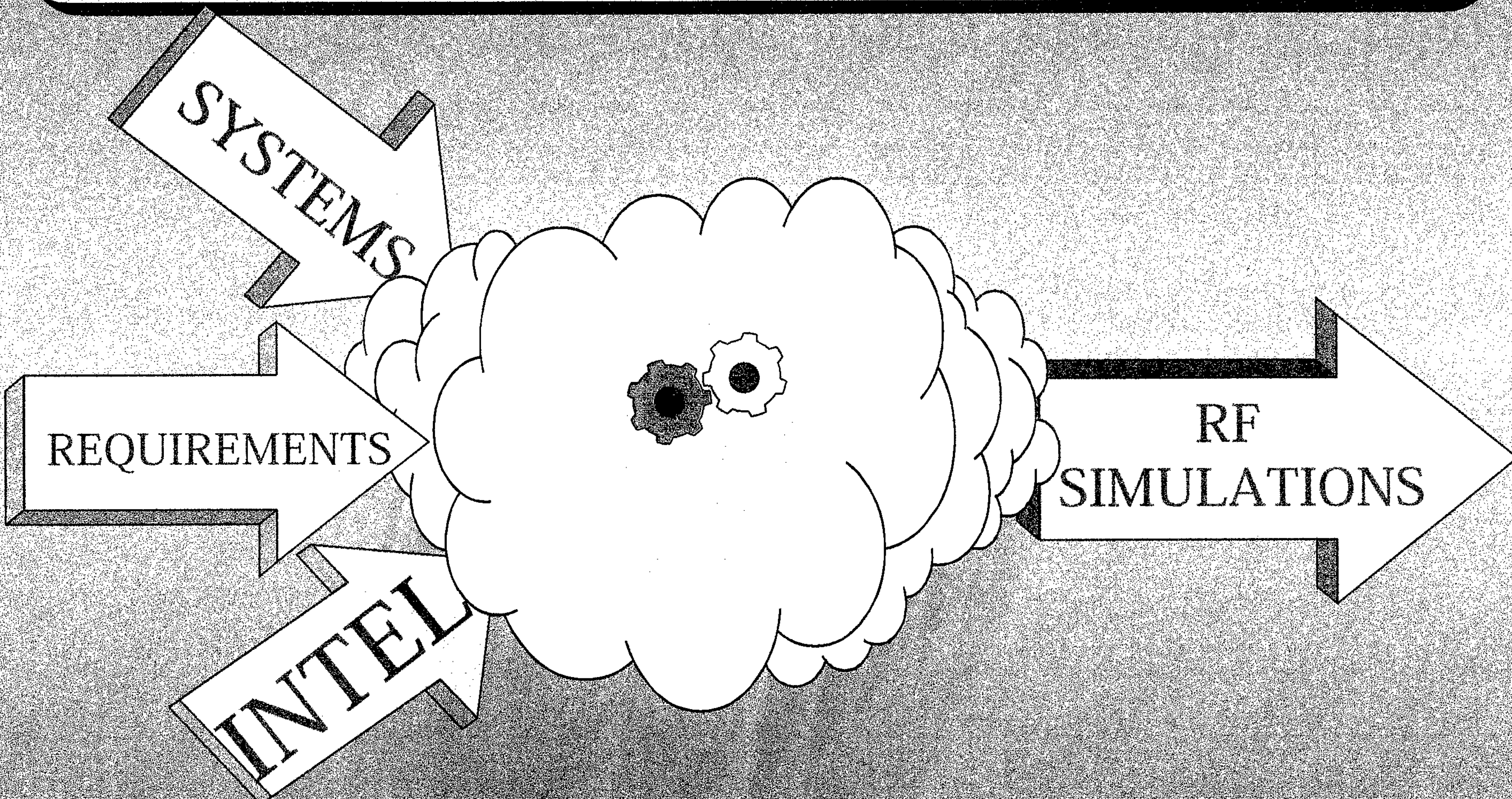
- incomplete & often changing
- cost & resource constraints
- platform variations & capabilities/limitations

LNEV 14

Simulation BASICS



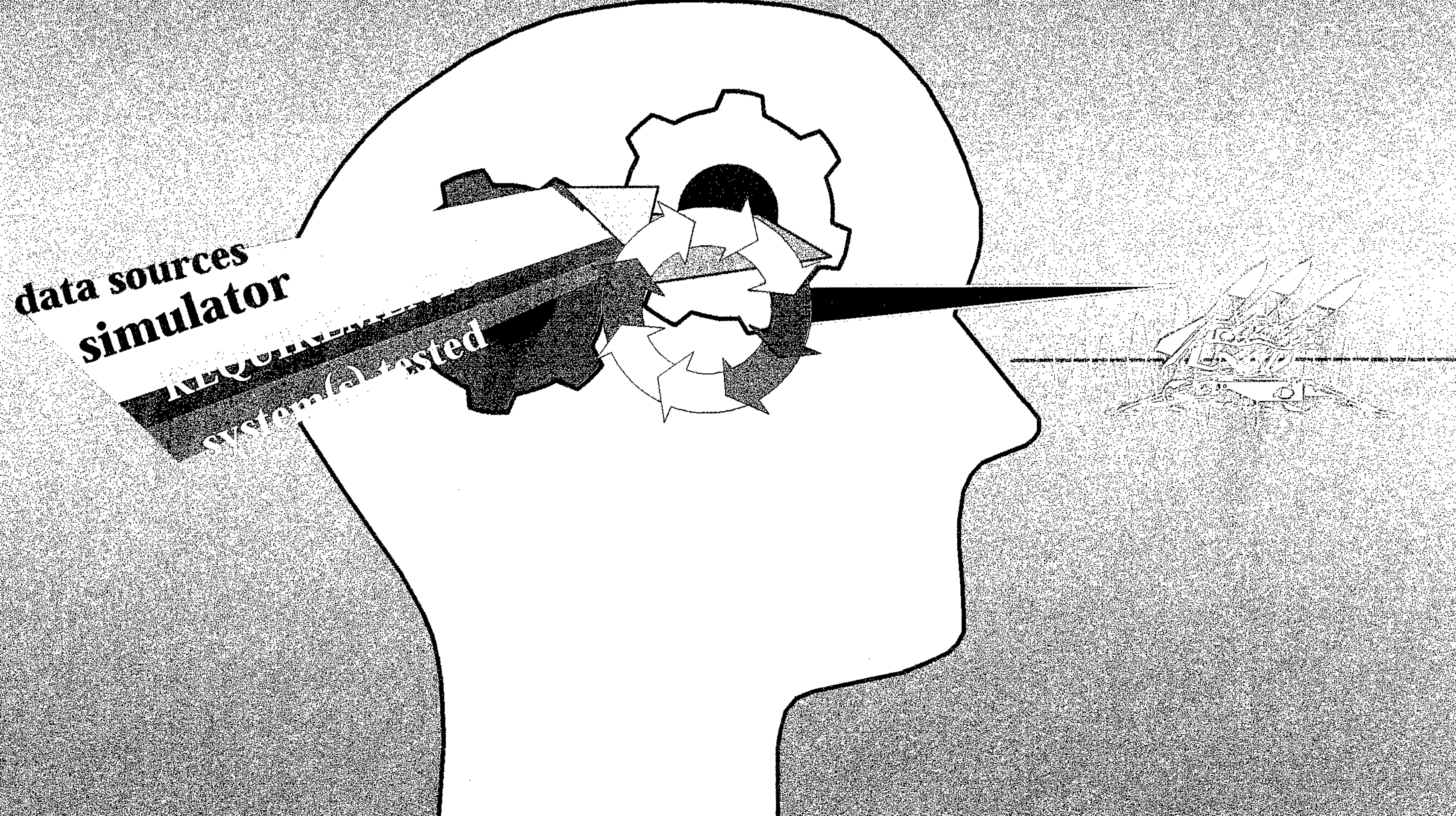
Developing Simulations "The PROCESS"



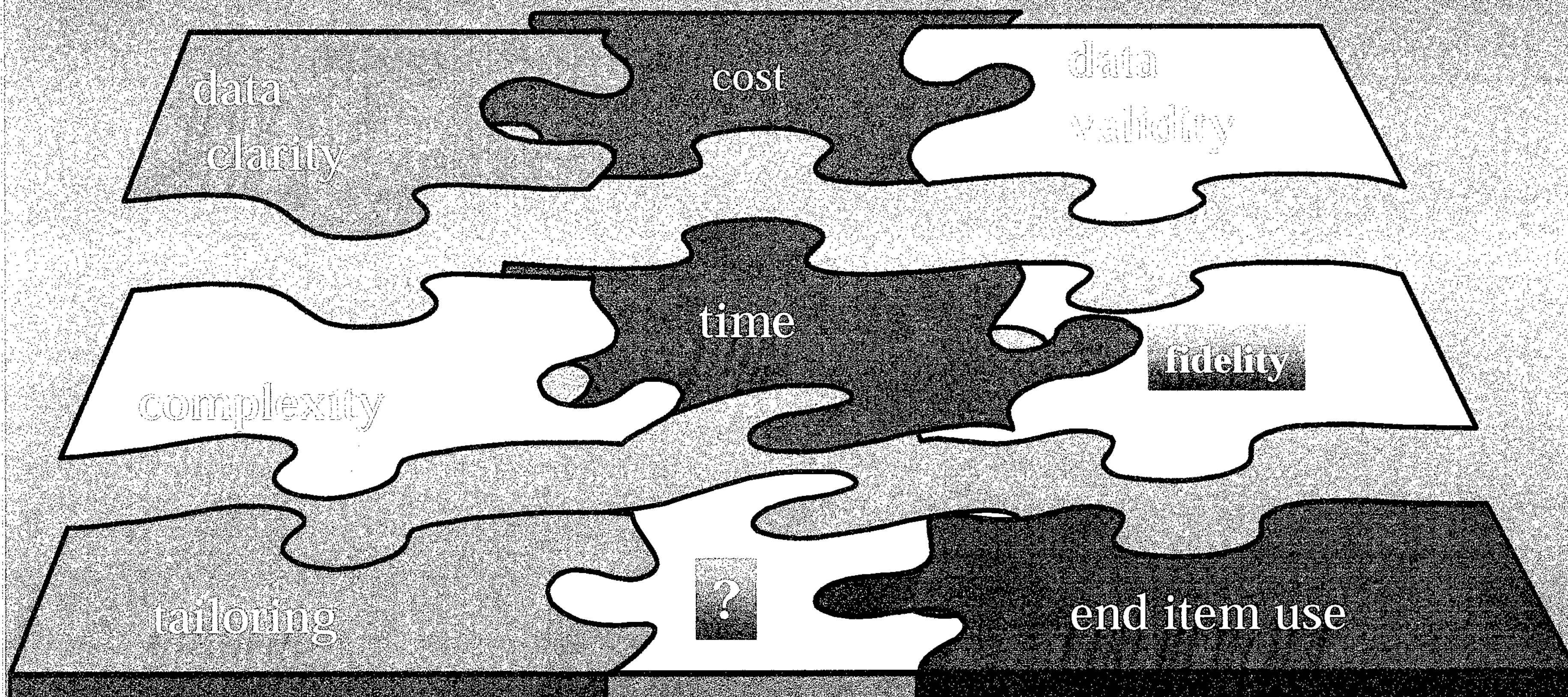
PROCESS

- Definition phase
- Implementation phase
- Application phase

Signal Definition



ISSUES

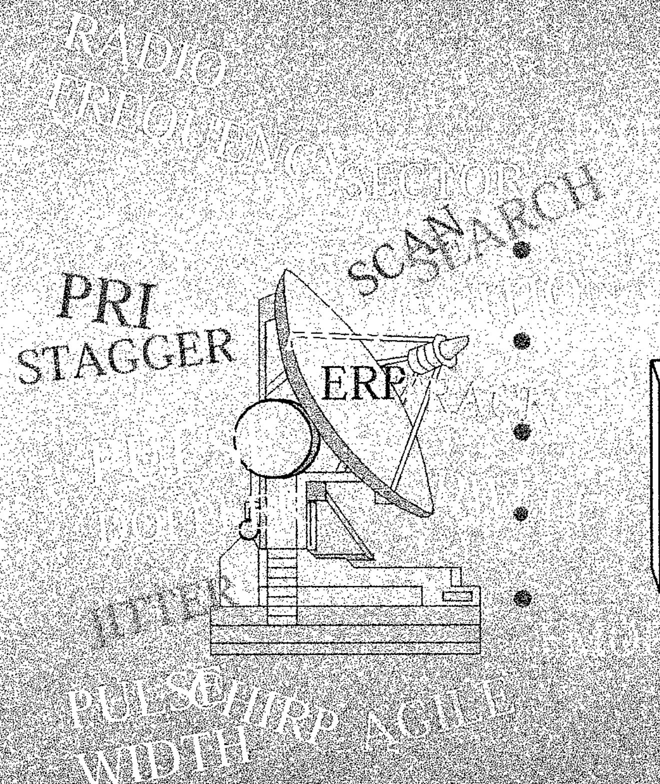


data clarity
cost
data validity
complexity
time
fidelity
tailoring
?
end item use

The 4 C's

- Constraints -- schedule, resource, cost
- Complexity -- requirements through dissemination
- Components -- expertise, methods, technology tools, partnerships
- Criticality -- "prime time" warfighter support

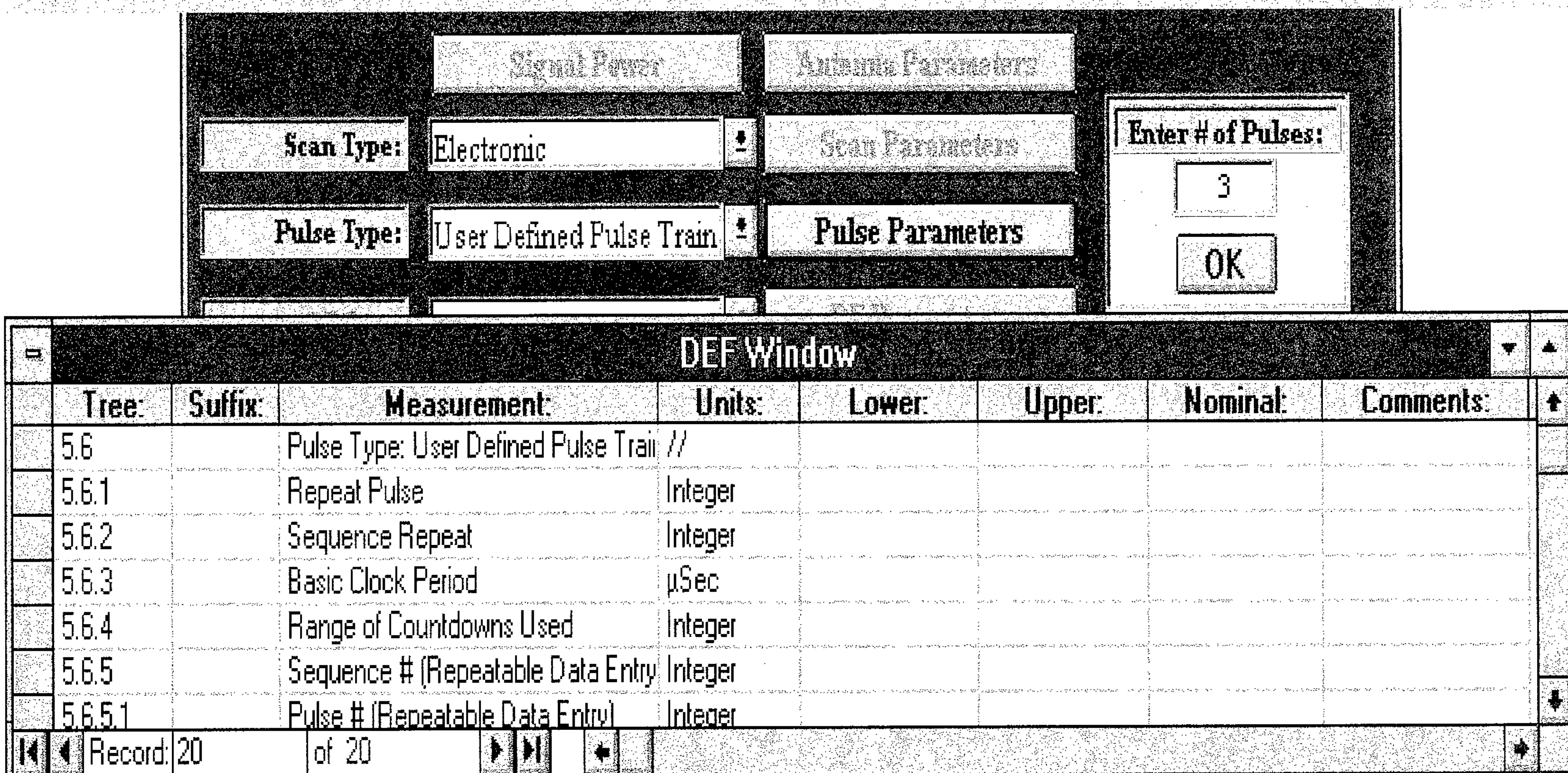
MODE Definition



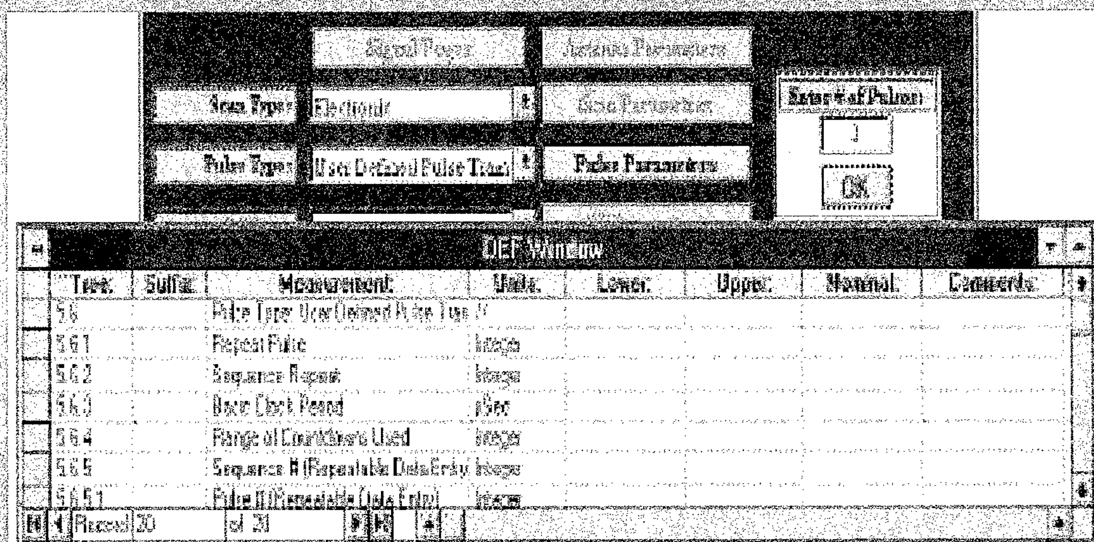
- mission
- system data
- system capabilities
- simulator
- experience

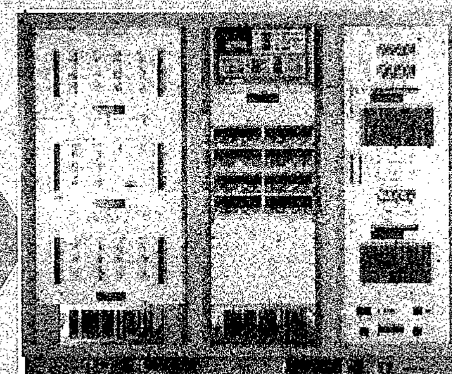
INDIVIDUAL RADAR MODES

"AUTOMATION"

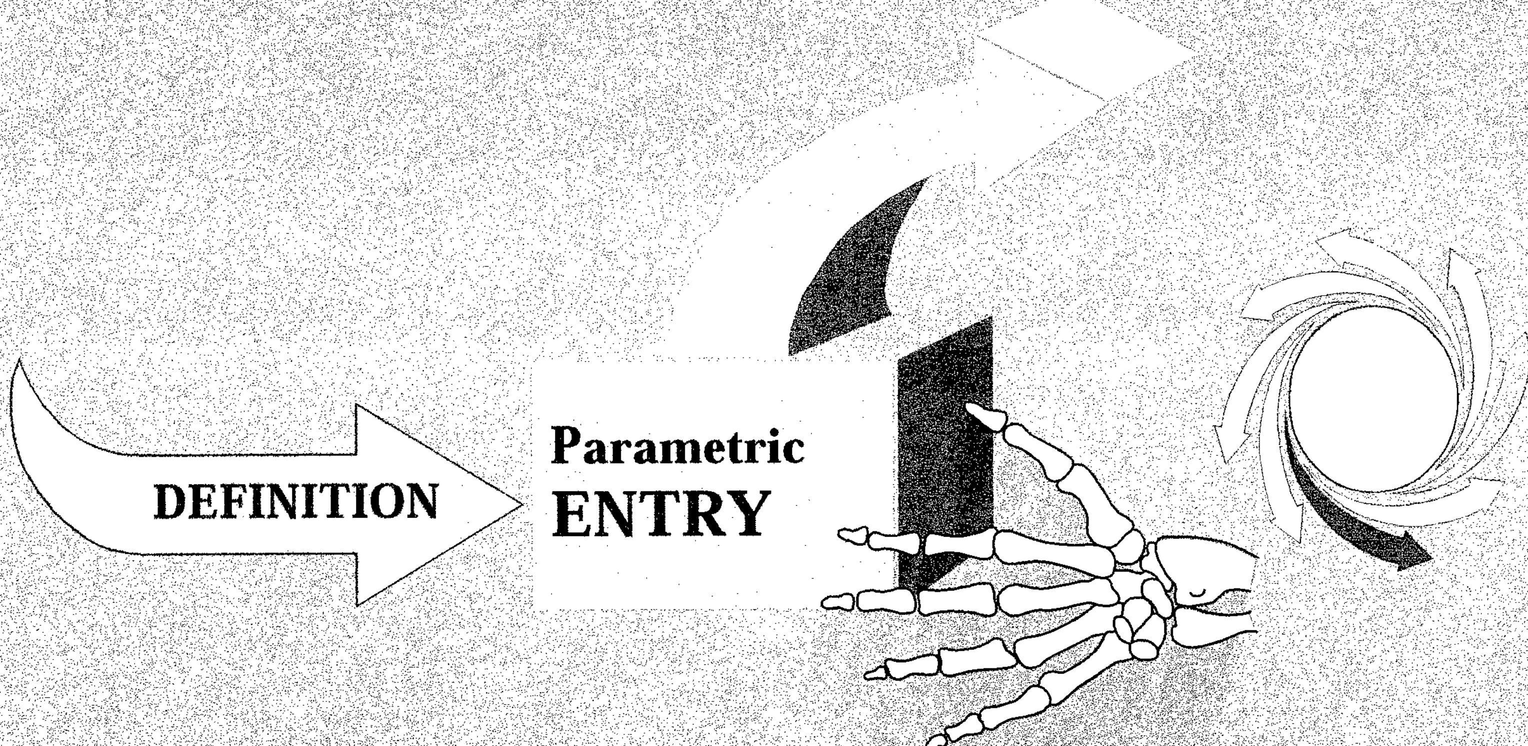

Scan Type:
Electronic
Pulse Type:
User Defined Pulse Train
Pulse Parameters
Enter # of Pulses:
3
OK
DEF Window
Tree: | Suffix: | Measurement: | Units: | Lower: | Upper: | Nominal: | Comments:
5.6 | Pulse Type: User Defined Pulse Trai | //
5.6.1 | Repeat Pulse | Integer
5.6.2 | Sequence Repeat | Integer
5.6.3 | Basic Clock Period | µSec
5.6.4 | Range of Countdowns Used | Integer
5.6.5 | Sequence # (Repeatable Data Entry | Integer
5.6.5.1 | Pulse # (Repeatable Data Entry) | Integer
Record: 20 of 20

Signal Implementation

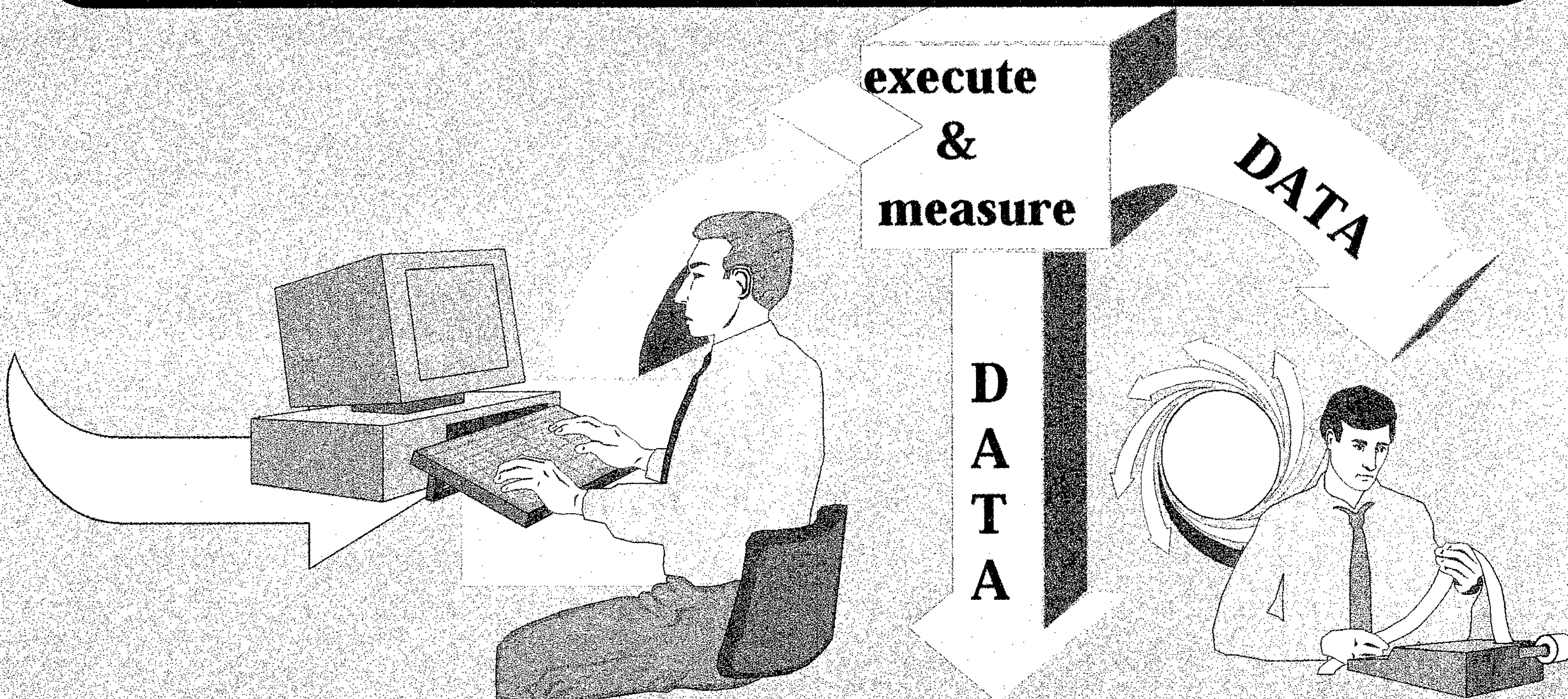




IMPLEMENTATION



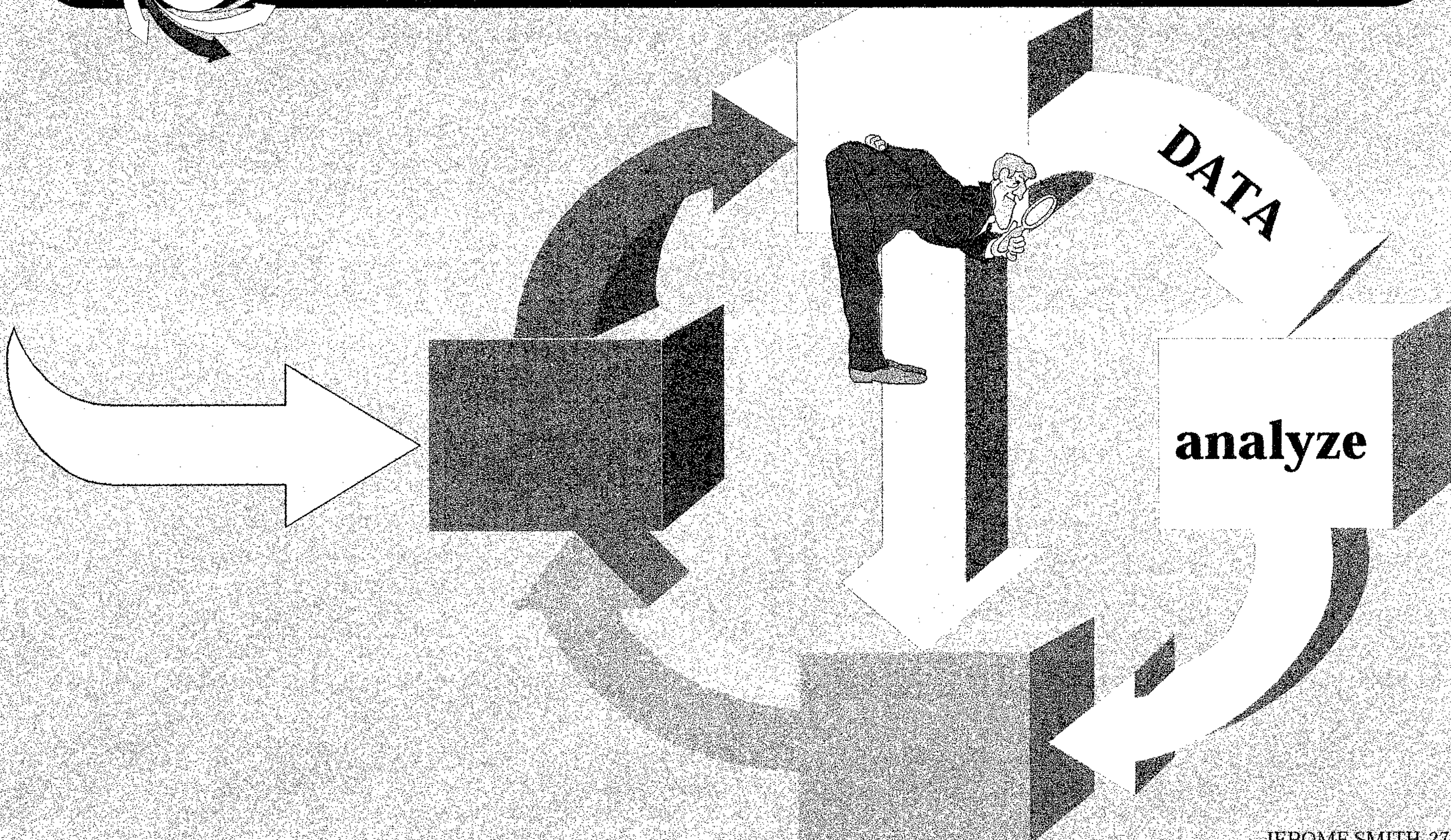
IMPLEMENTATION



JEROME SMITH-26

LNEV-25

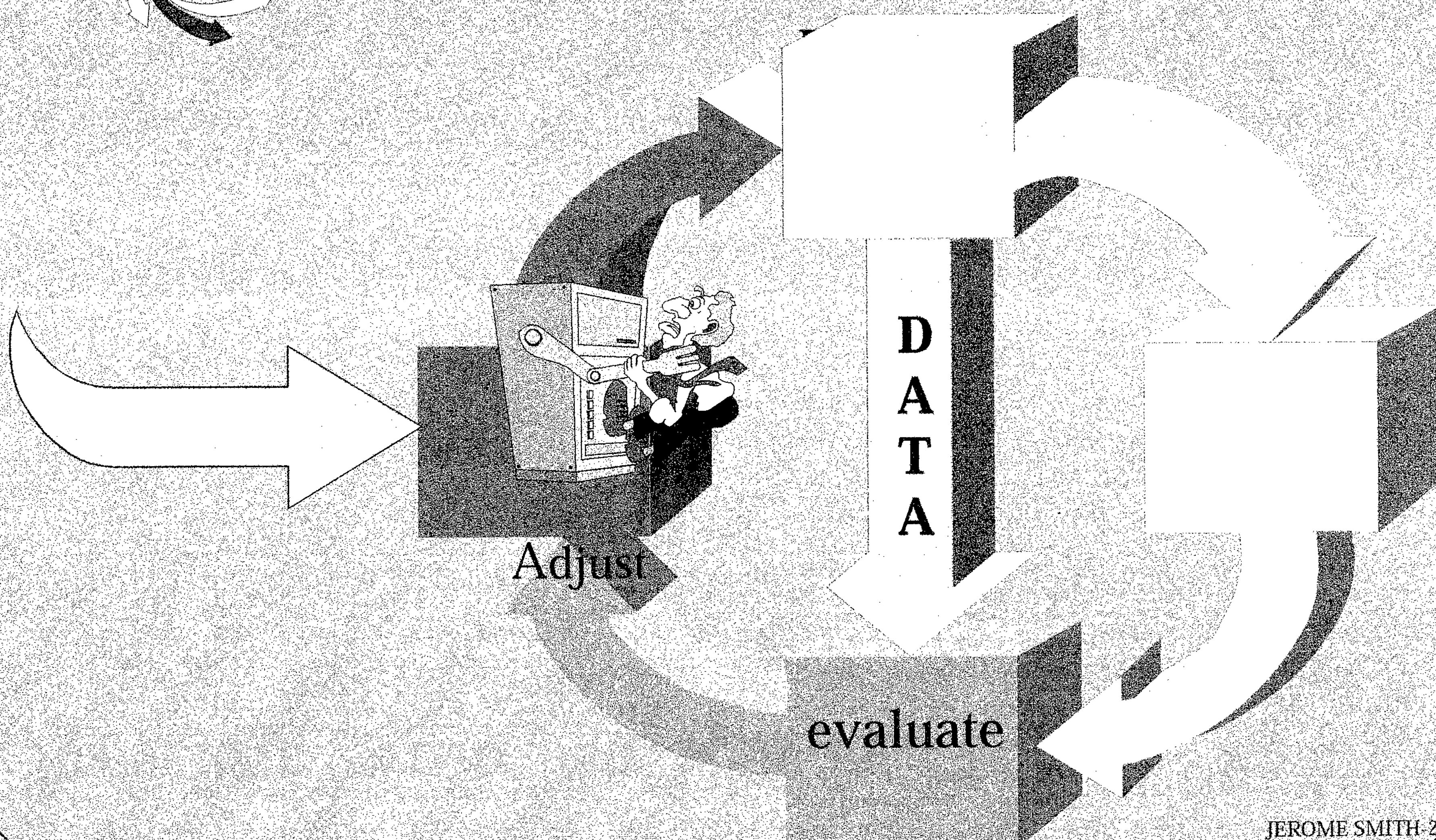
IMPLEMENTATION

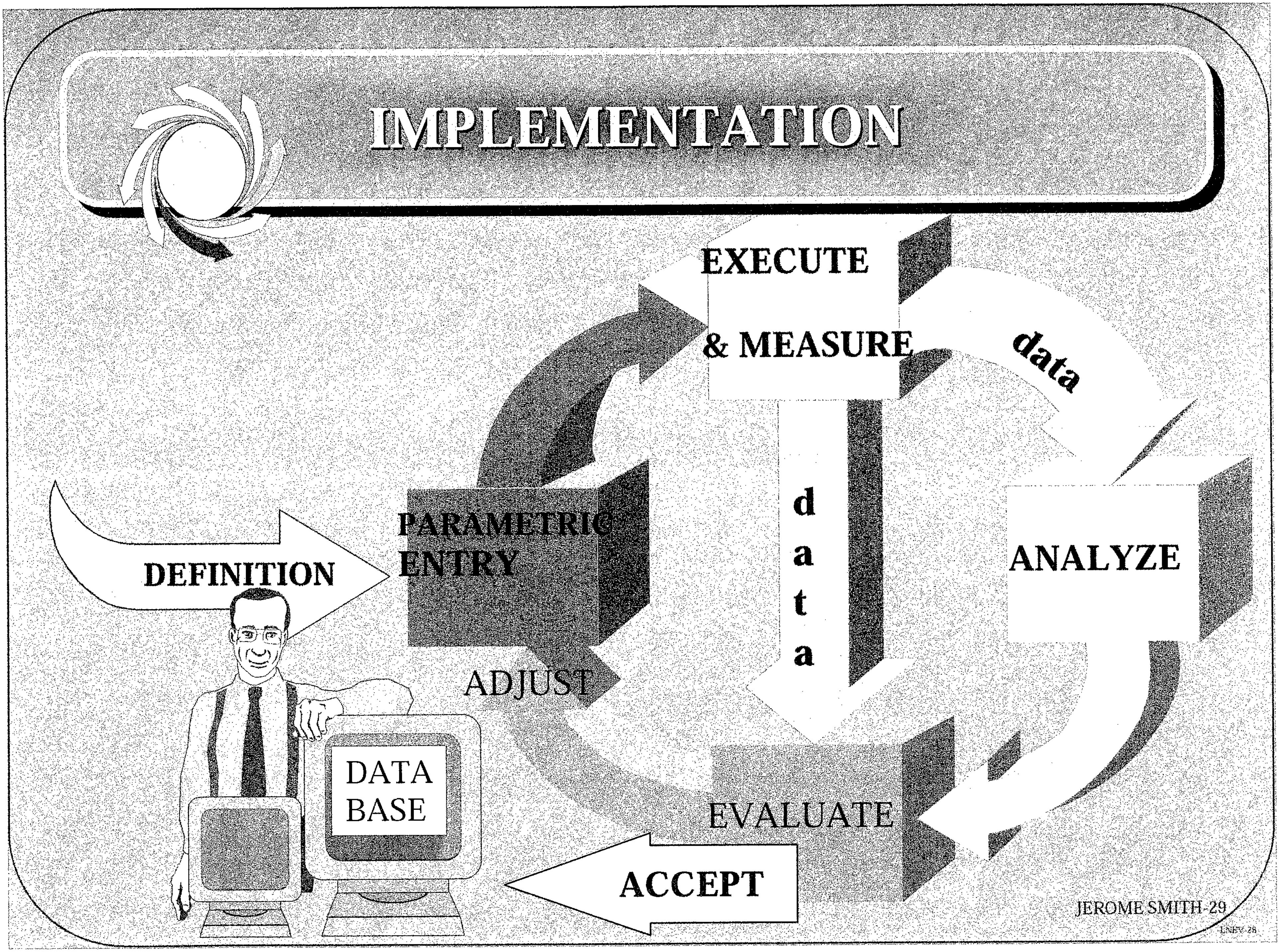


JERROME SMITH-27

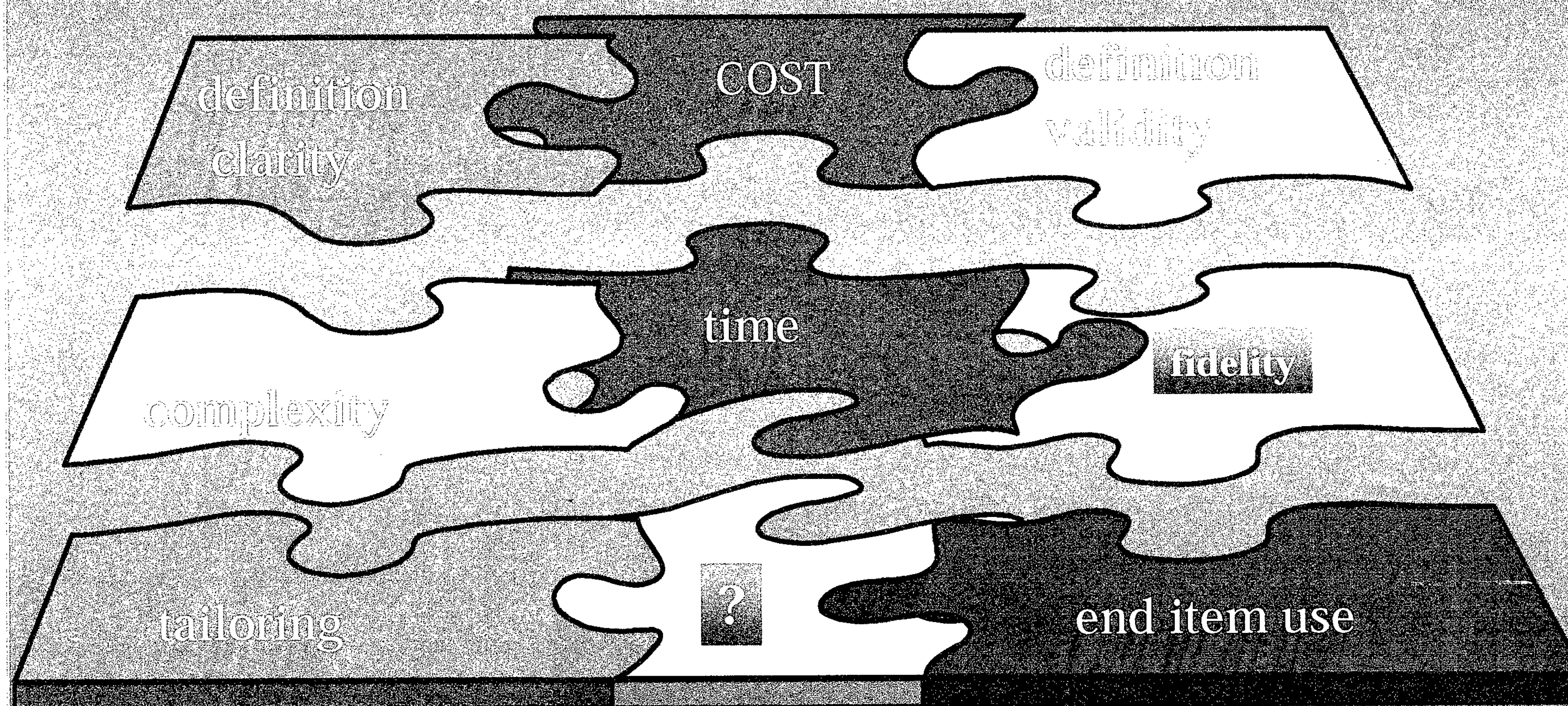
LNEV-26

IMPLEMENTATION



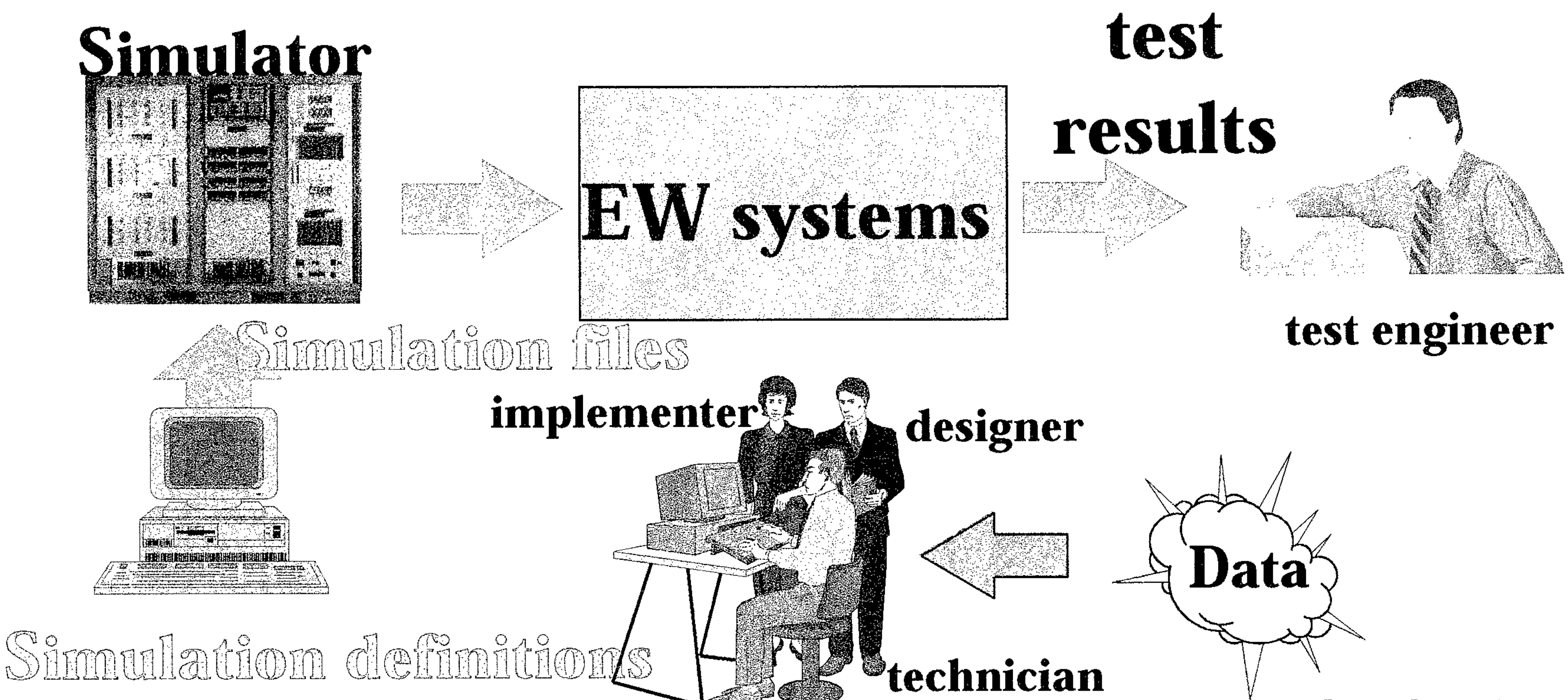

IMPLEMENTATION
EXECUTE
& MEASURE
data
PARAMETRIC
ENTRY
DEFINITION
d
a
t
a
ANALYZE
ADJUST
DATA
BASE
EVALUATE
ACCEPT
JEROME SMITH-29

ISSUES



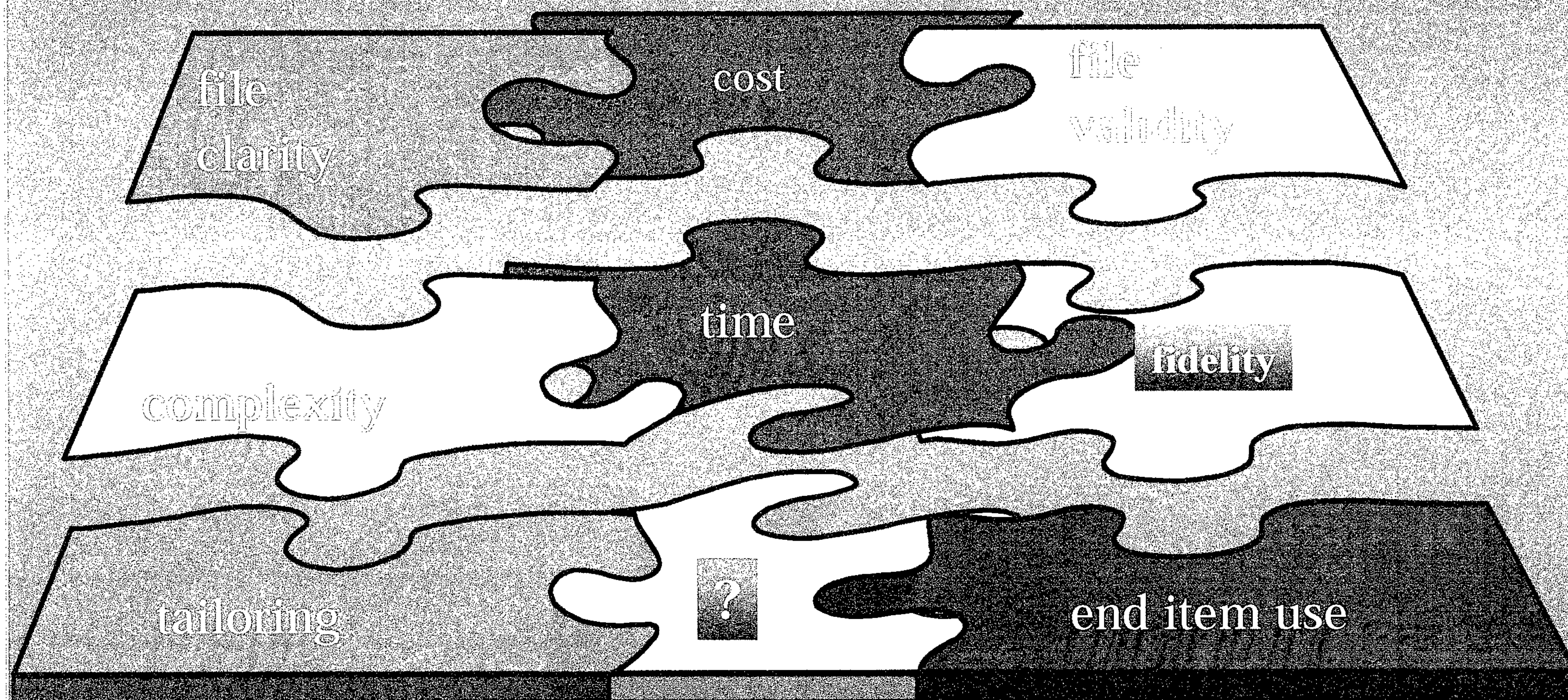
definition clarity
COST
definition validity
time
fidelity
complexity
tailoring
?
end item use

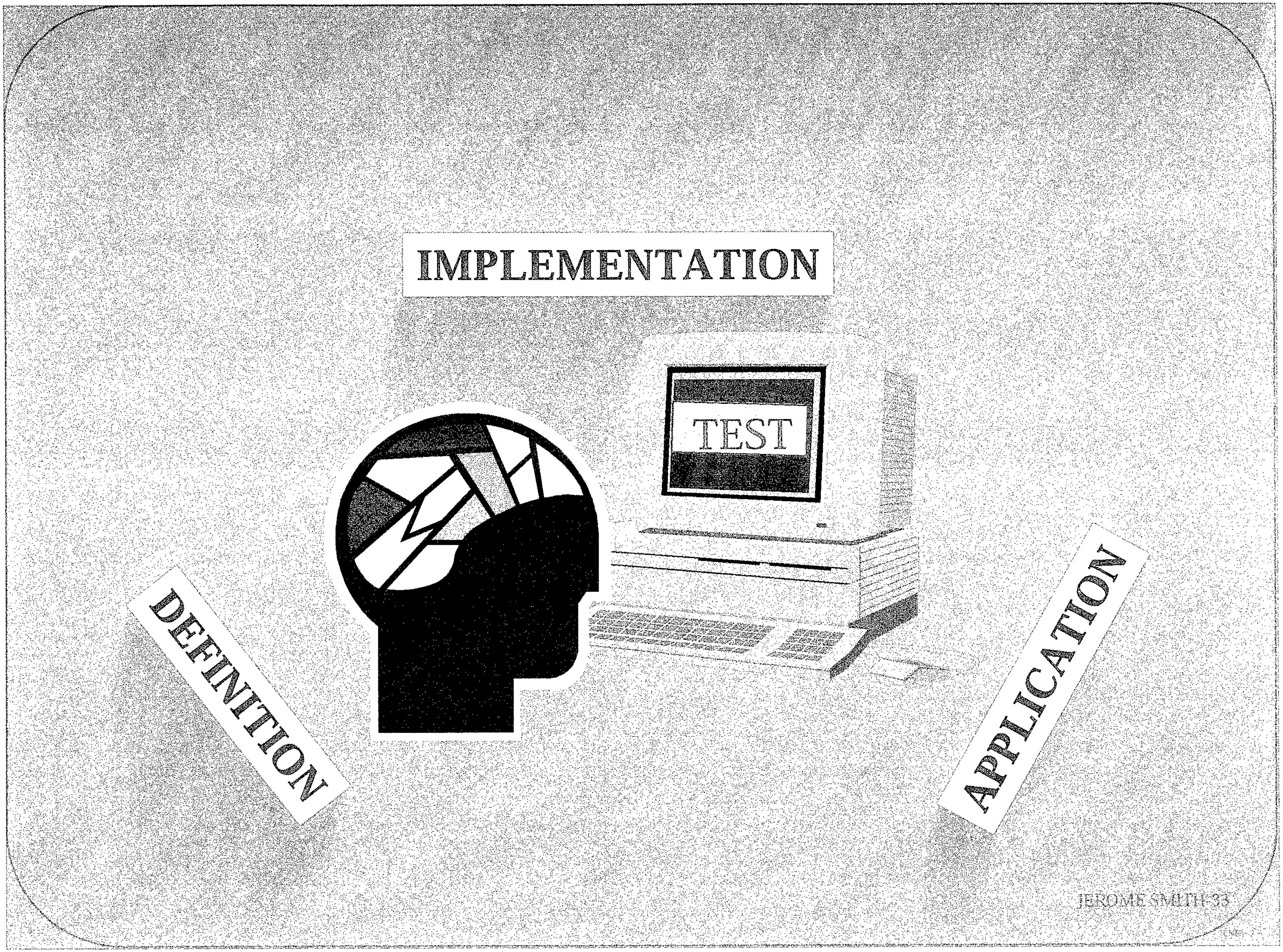
APPLICATION



Jerome Smith-31

ISSUES


file
clarity
cost
file
validity
complexity
time
fidelity
tailoring
?
end item use

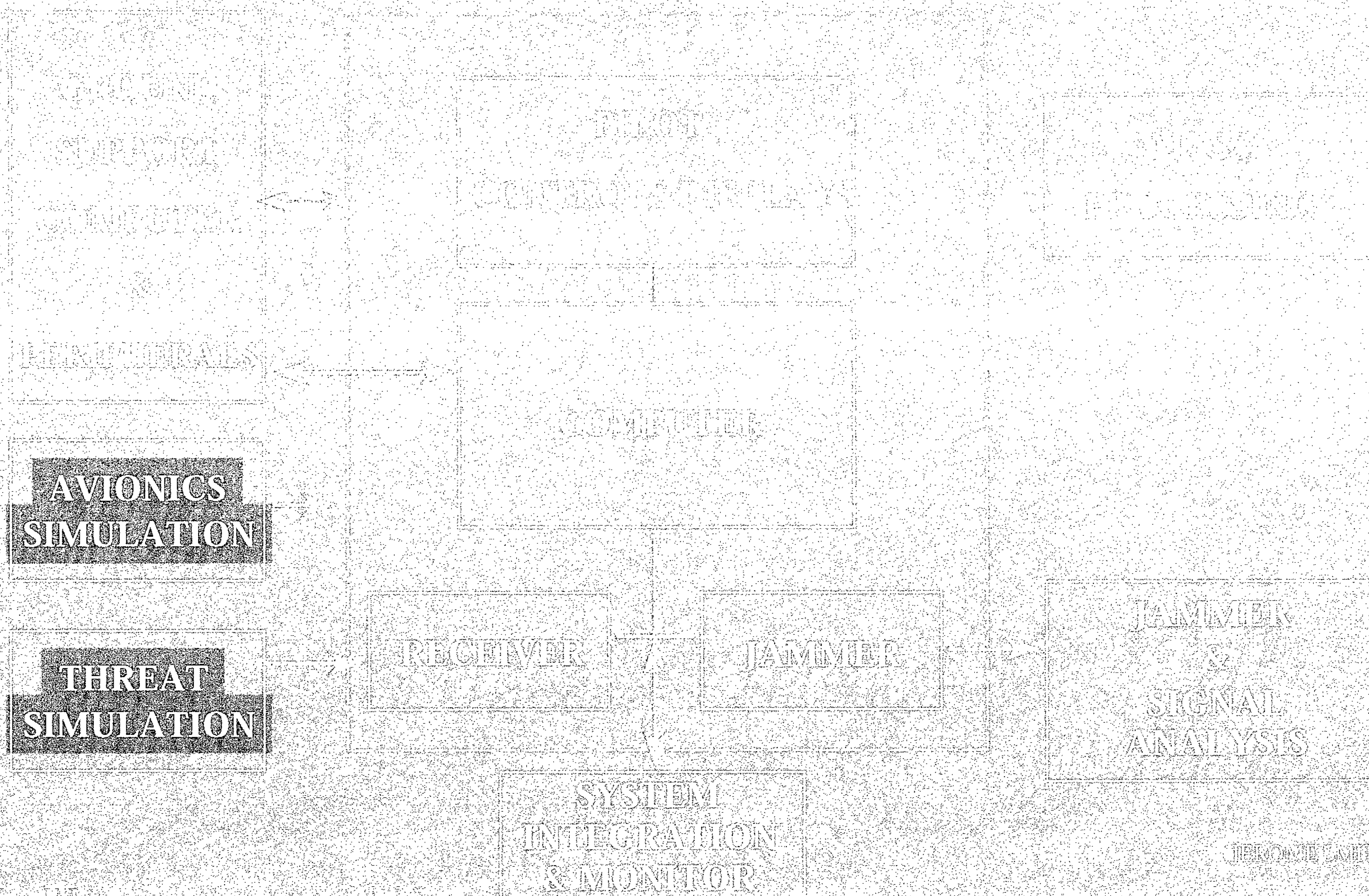

IMPLEMENTATION
TEST
DEFINITION
APPLICATION
JEROME SMITH-33

TECHNOLOGY

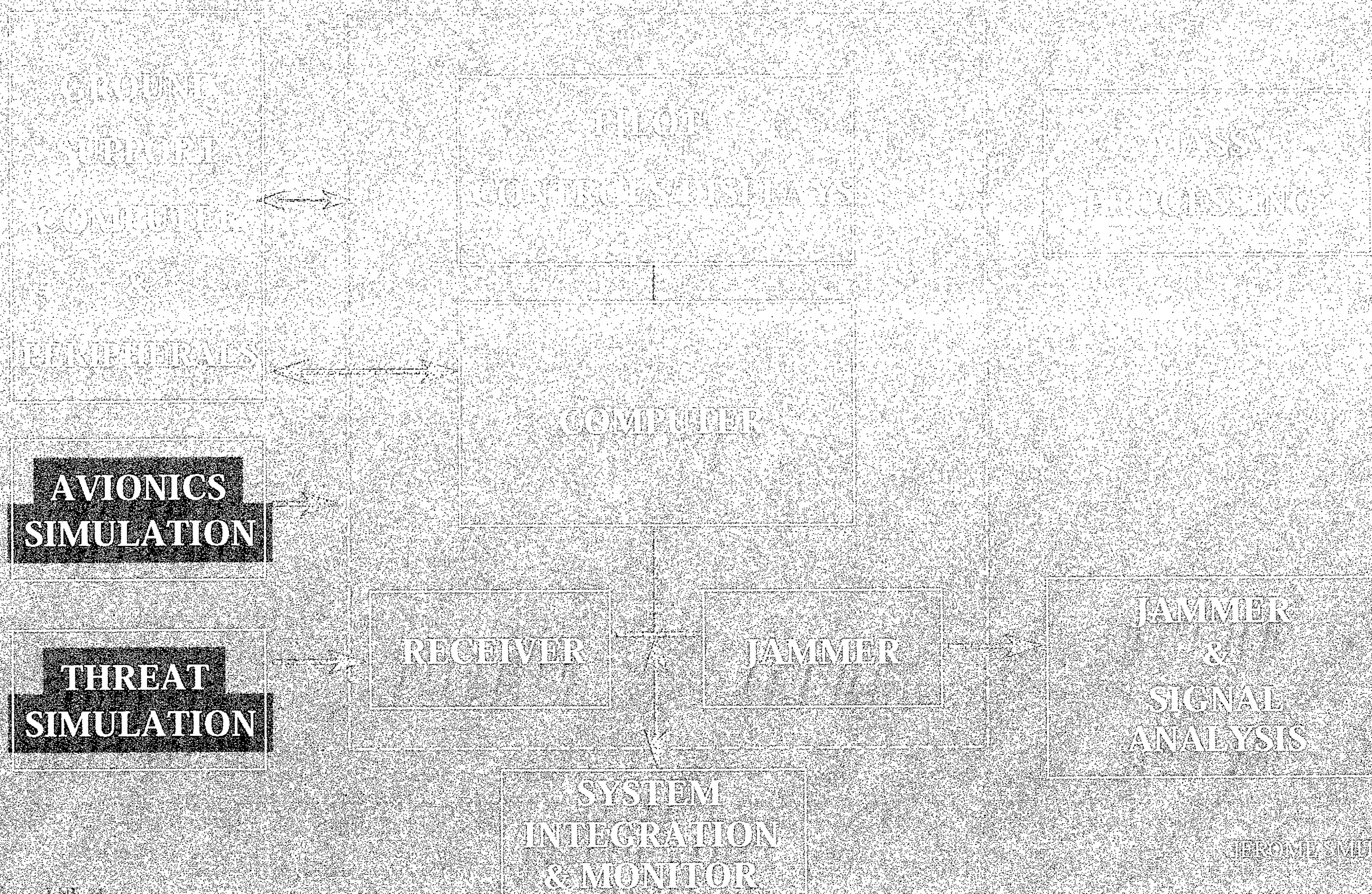
- SIMULATORS
- DATABASE TOOLS
- "AUTOMATION"

LNEV-3

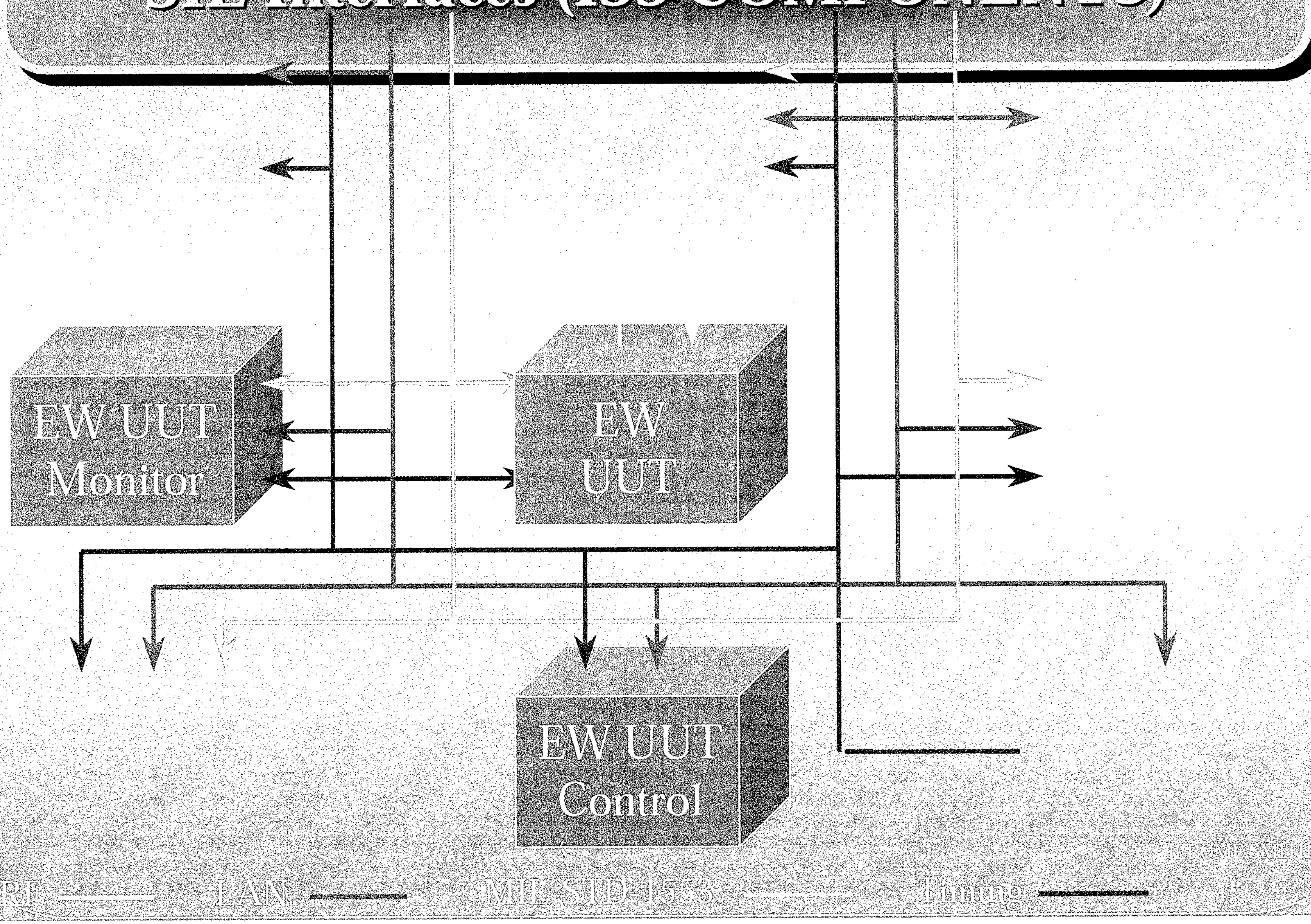
EWAISF
Integration Support Station (ISS)



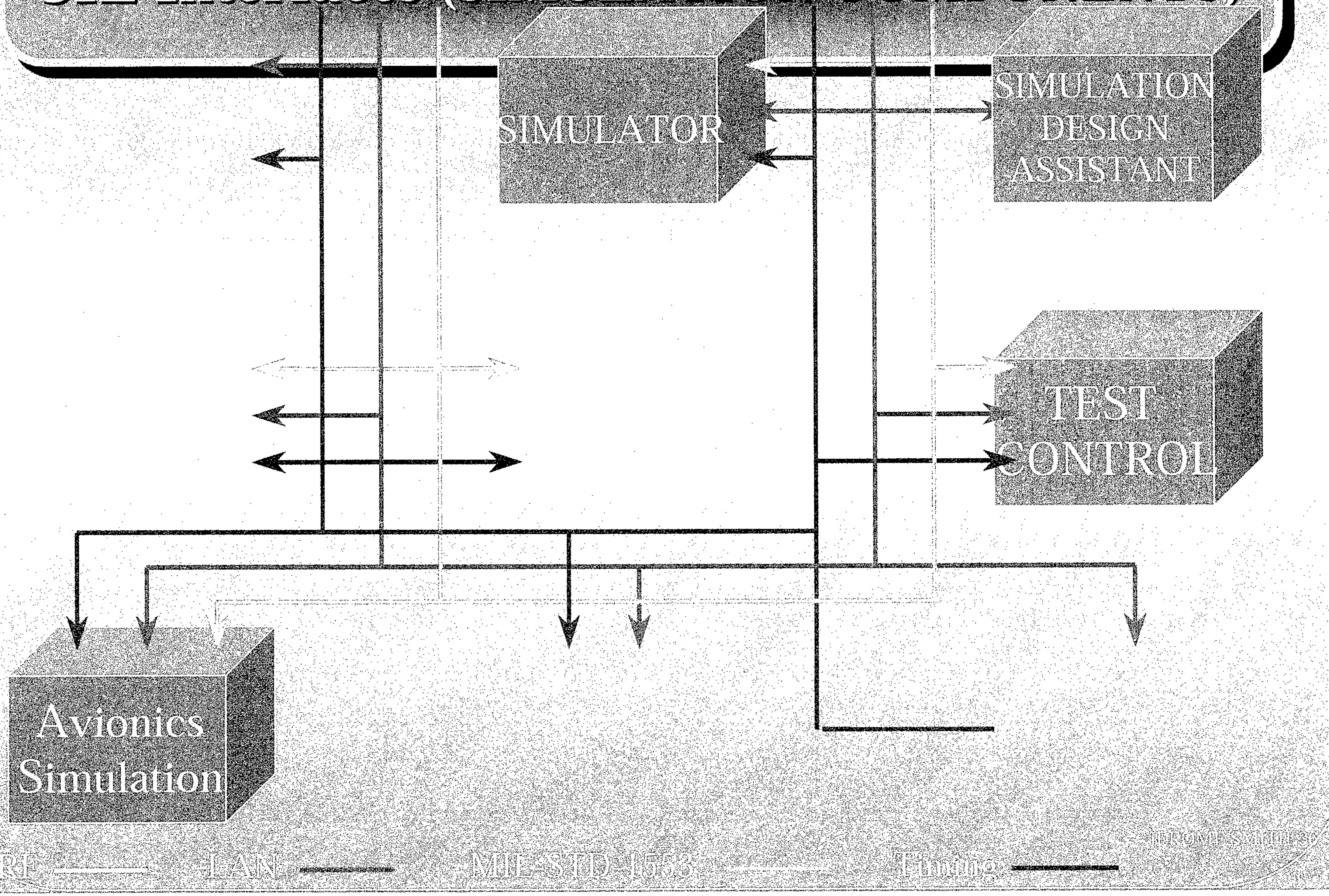
EWAISF
Integration Support Station (ISS)



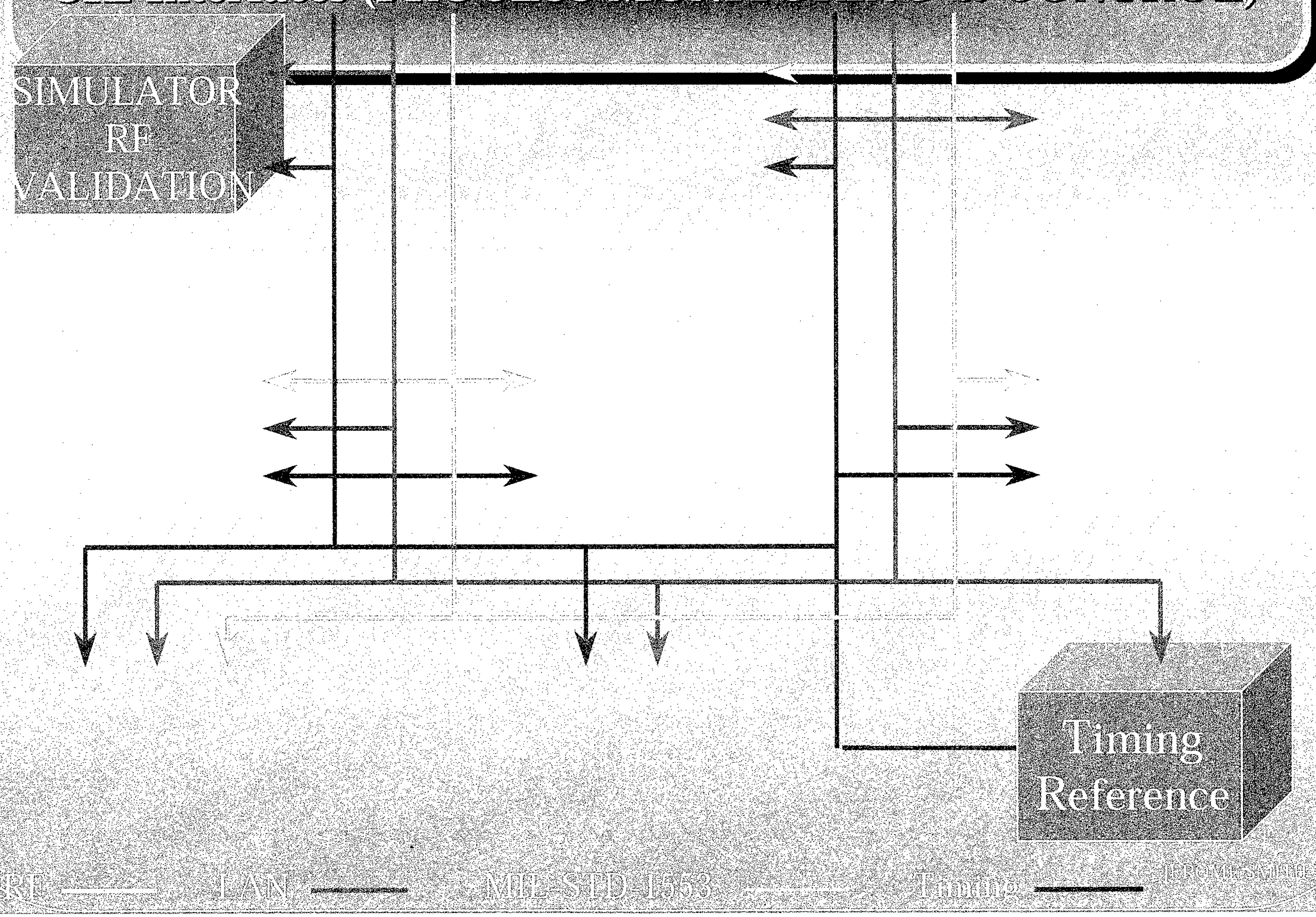
SIL Interfaces (ISS COMPONENTS)



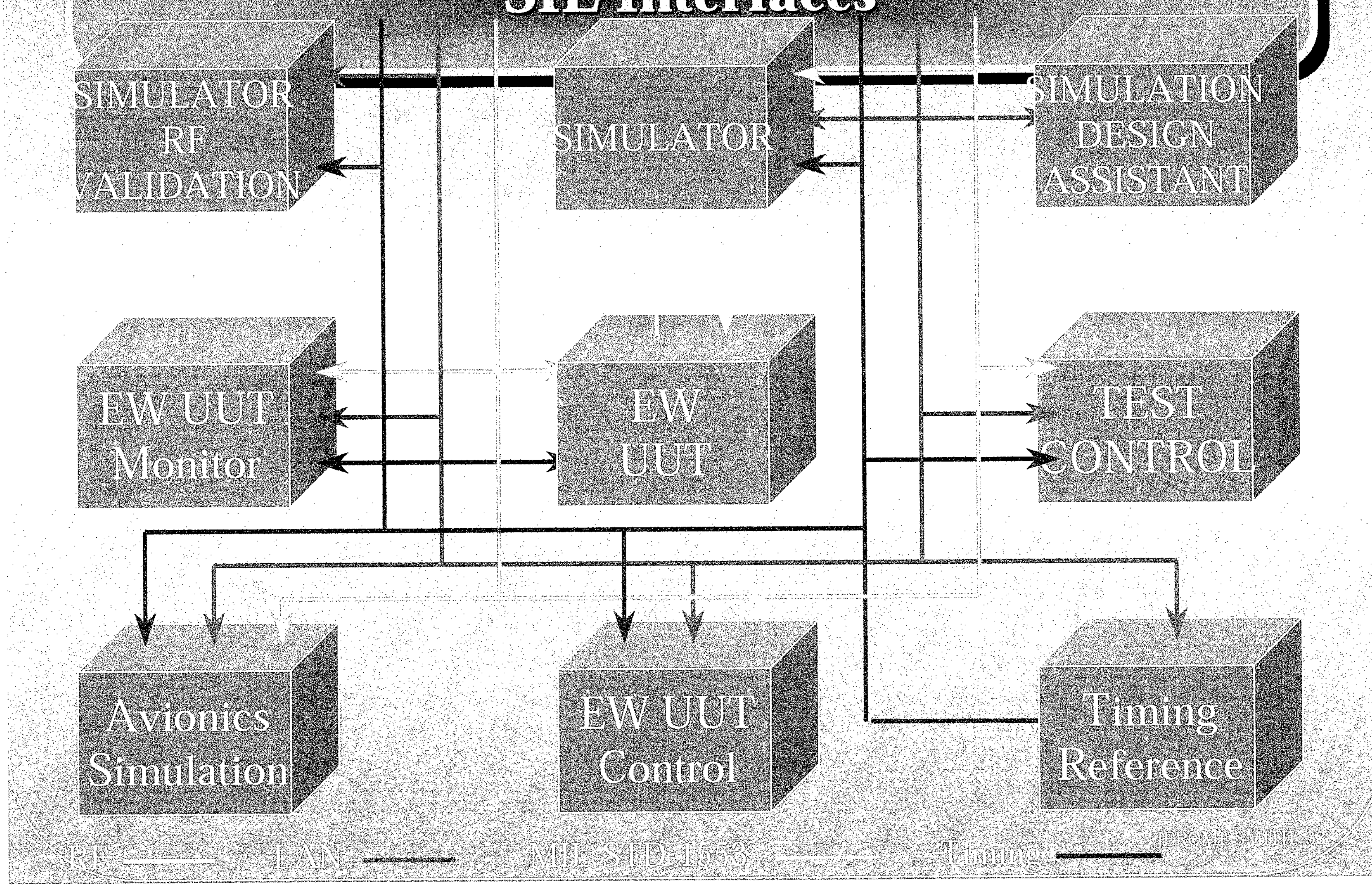
SIL Interfaces (SIMULATION COMPONENTS)



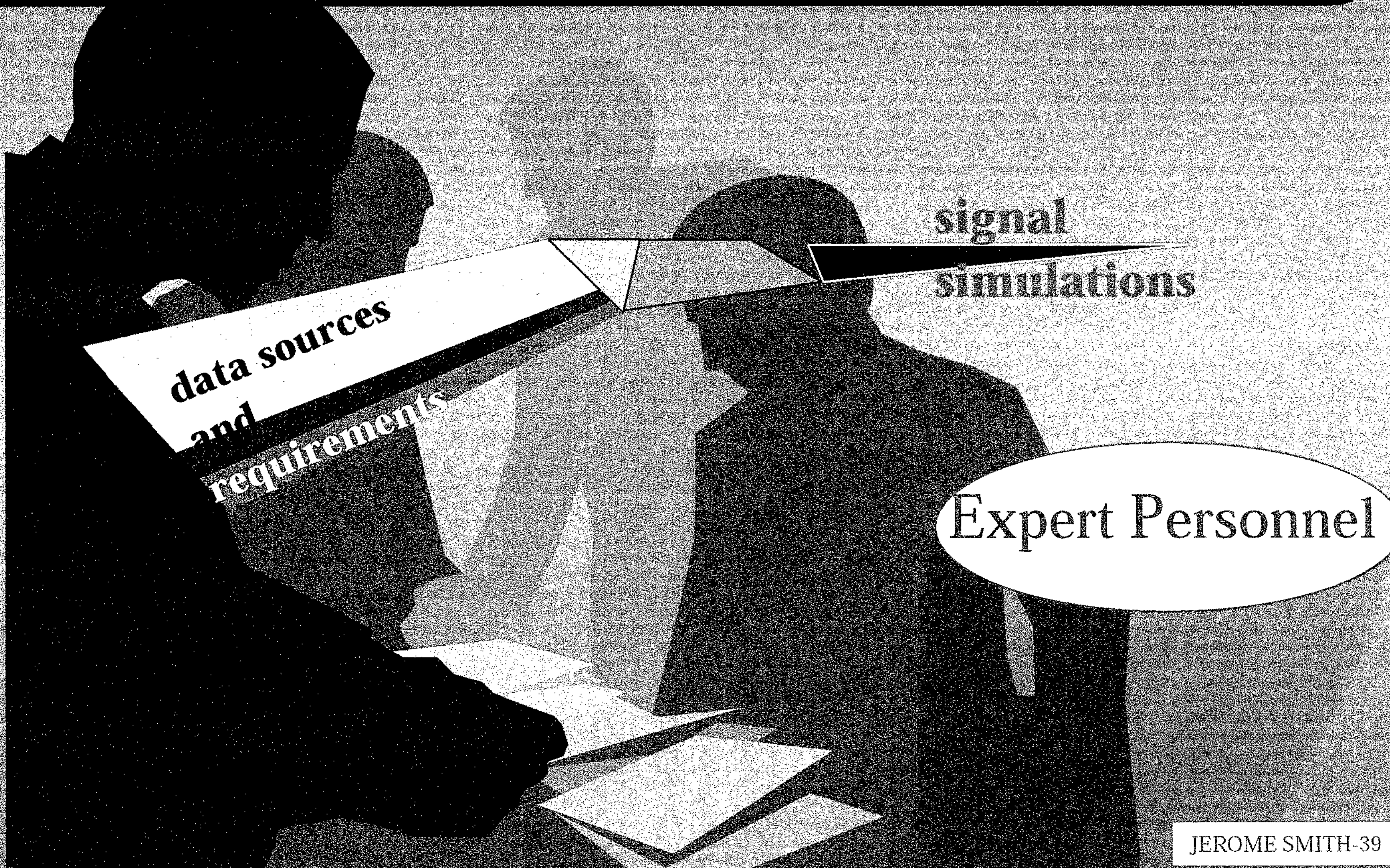
SIL Interfaces (PROCESS MONITORING & CONTROL)



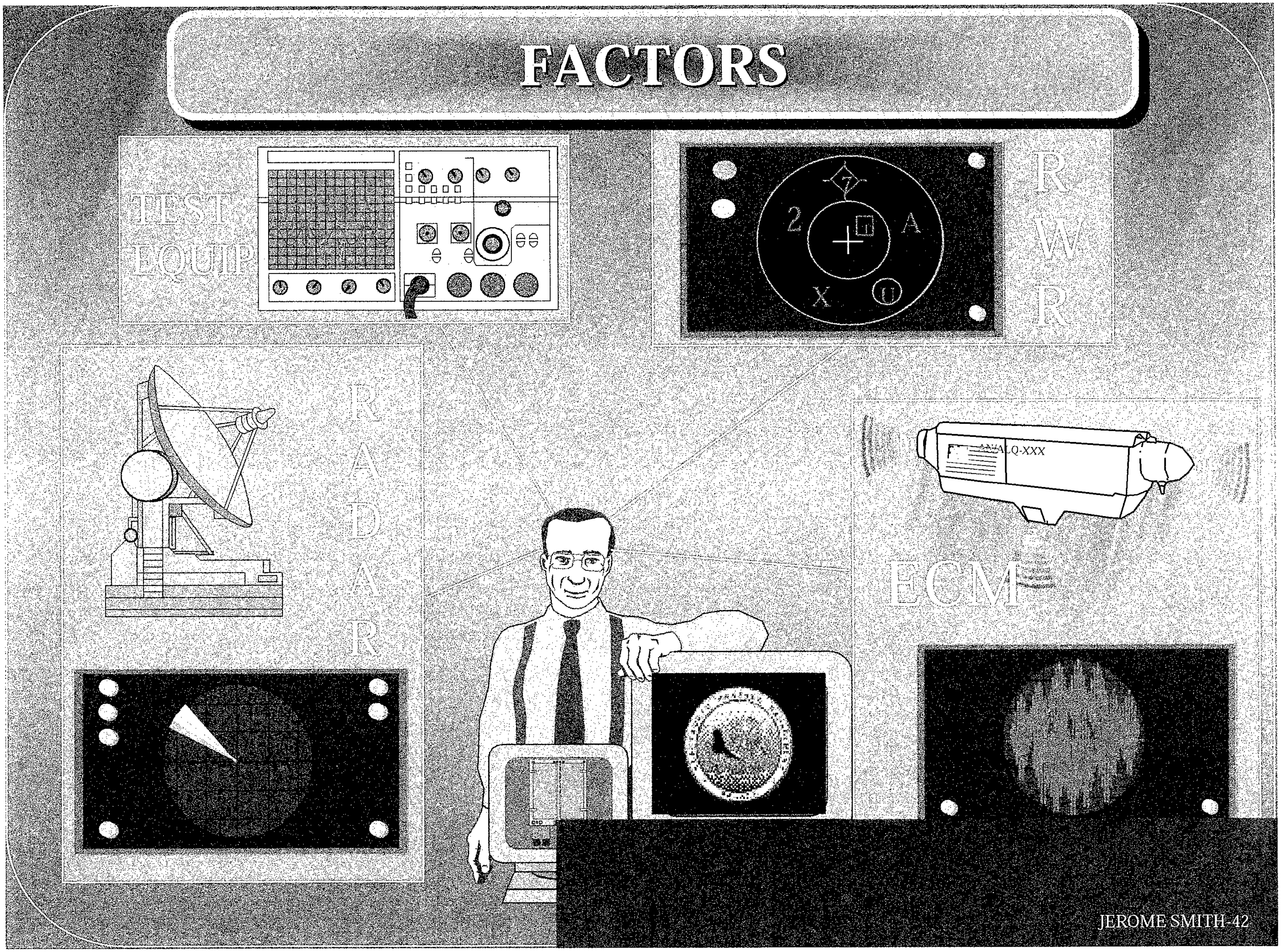
SIL Interfaces

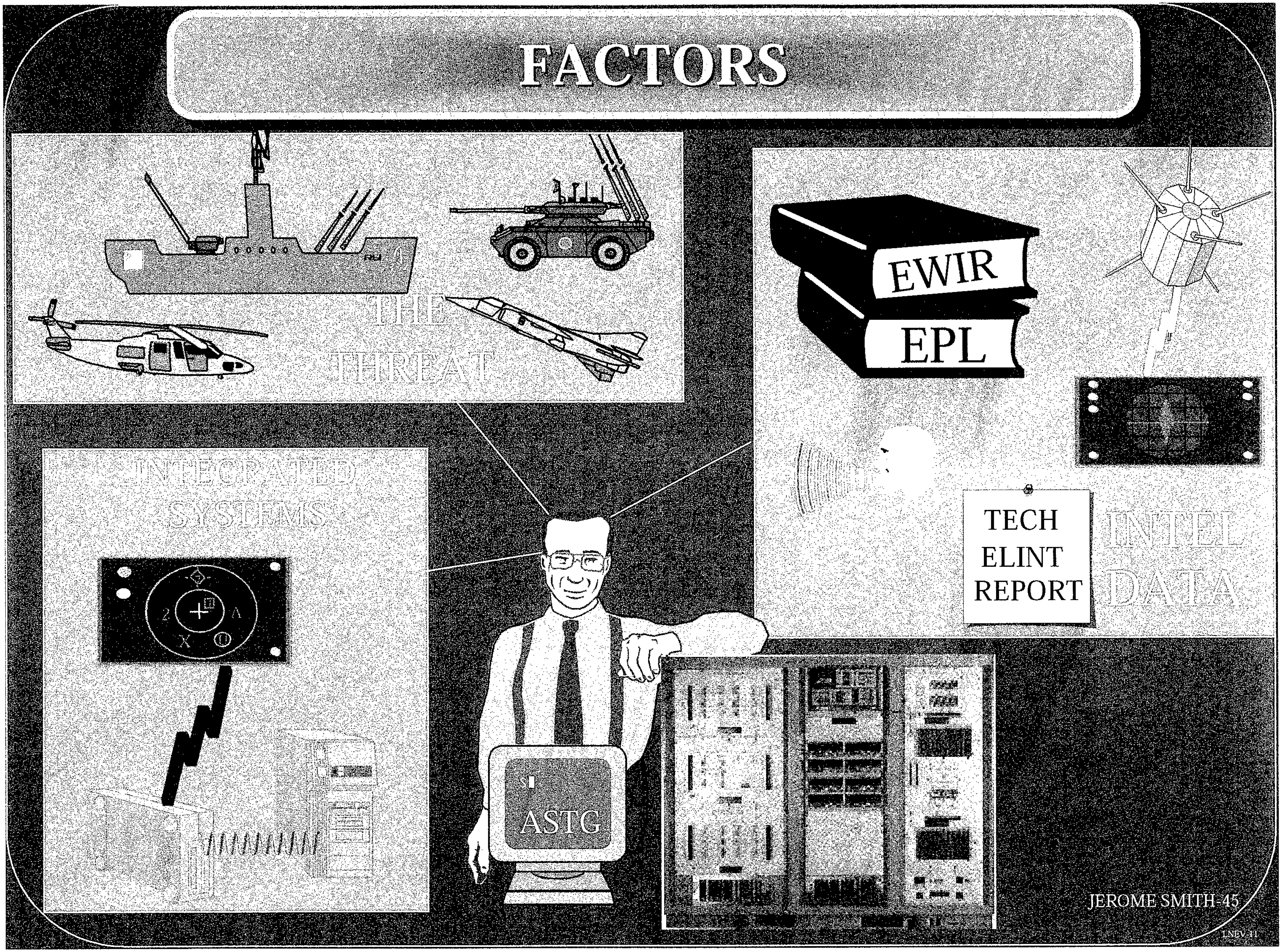


Simulation Basics

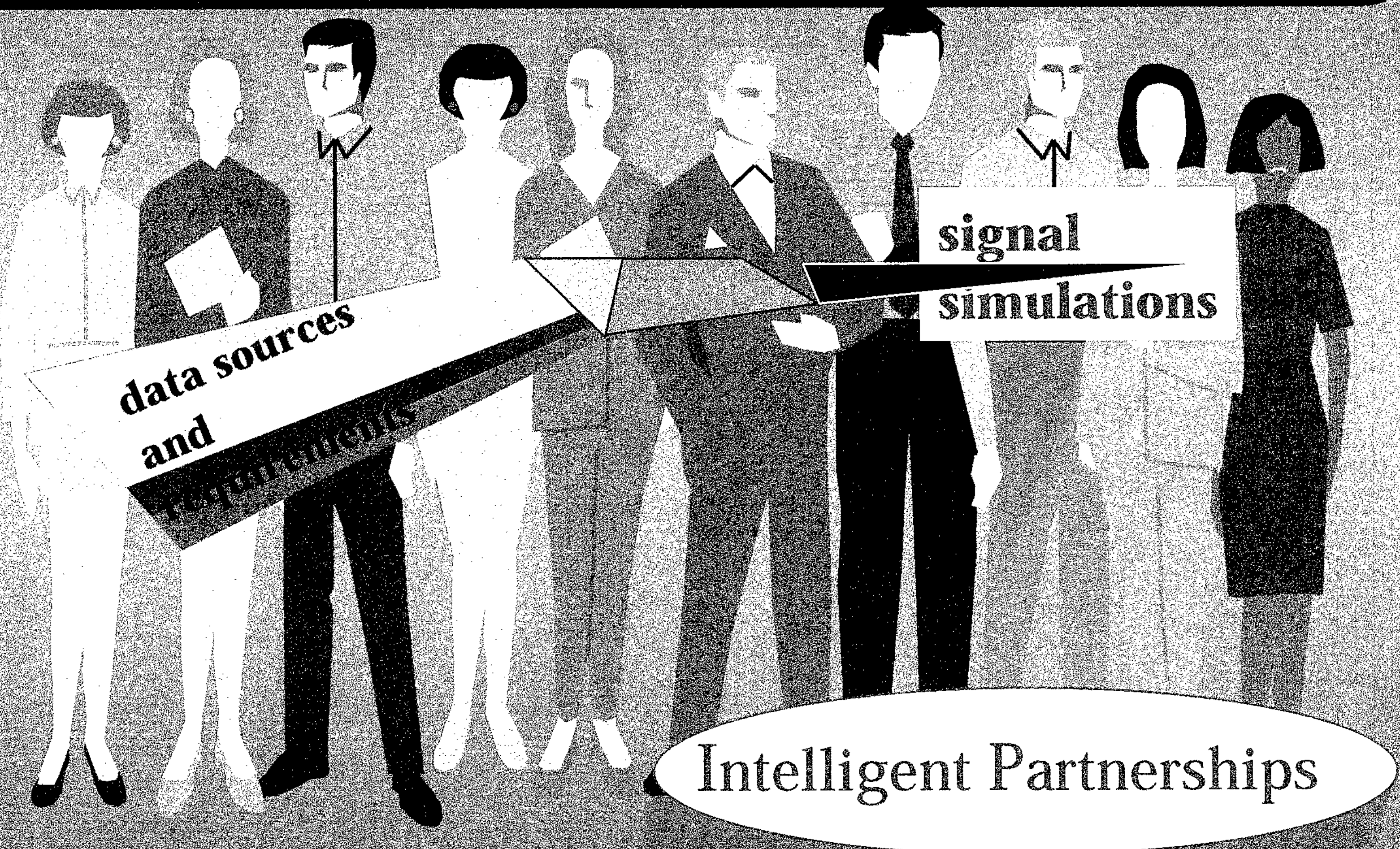


JEROME SMITH-39

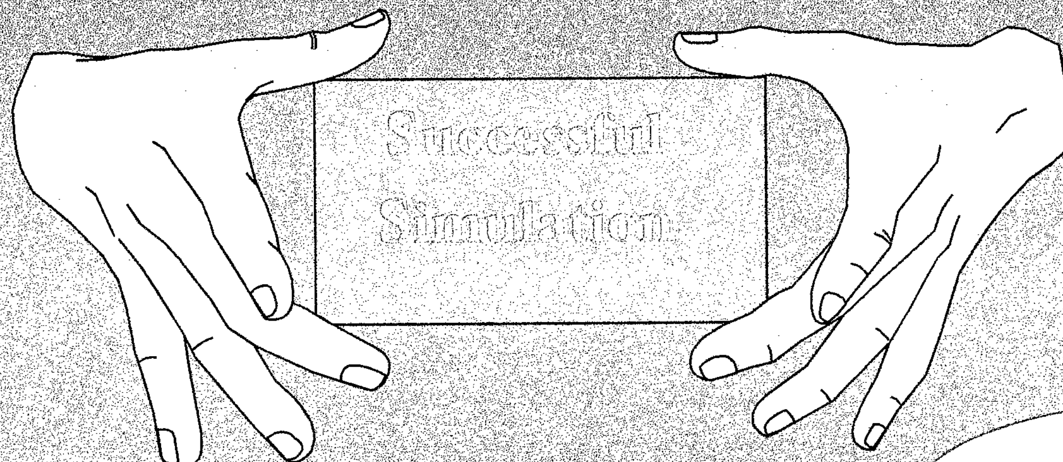

FACTORS
TEST EQUIP
RWR
2
A
X
U
RADAR
AN/ALQ-XXX
ECM
JEROME SMITH-42


FACTORS
THE THREAT
INTEGRATED SYSTEMS
EWIR
EPL
TECH ELINT REPORT
INTEL DATA
ASTG
JEROME SMITH-45
LNEV-11

Simulation Basics



Simulation Basics



technological tools
&
effective processes

expert personnel

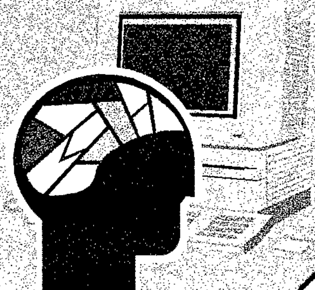
intelligent partnerships

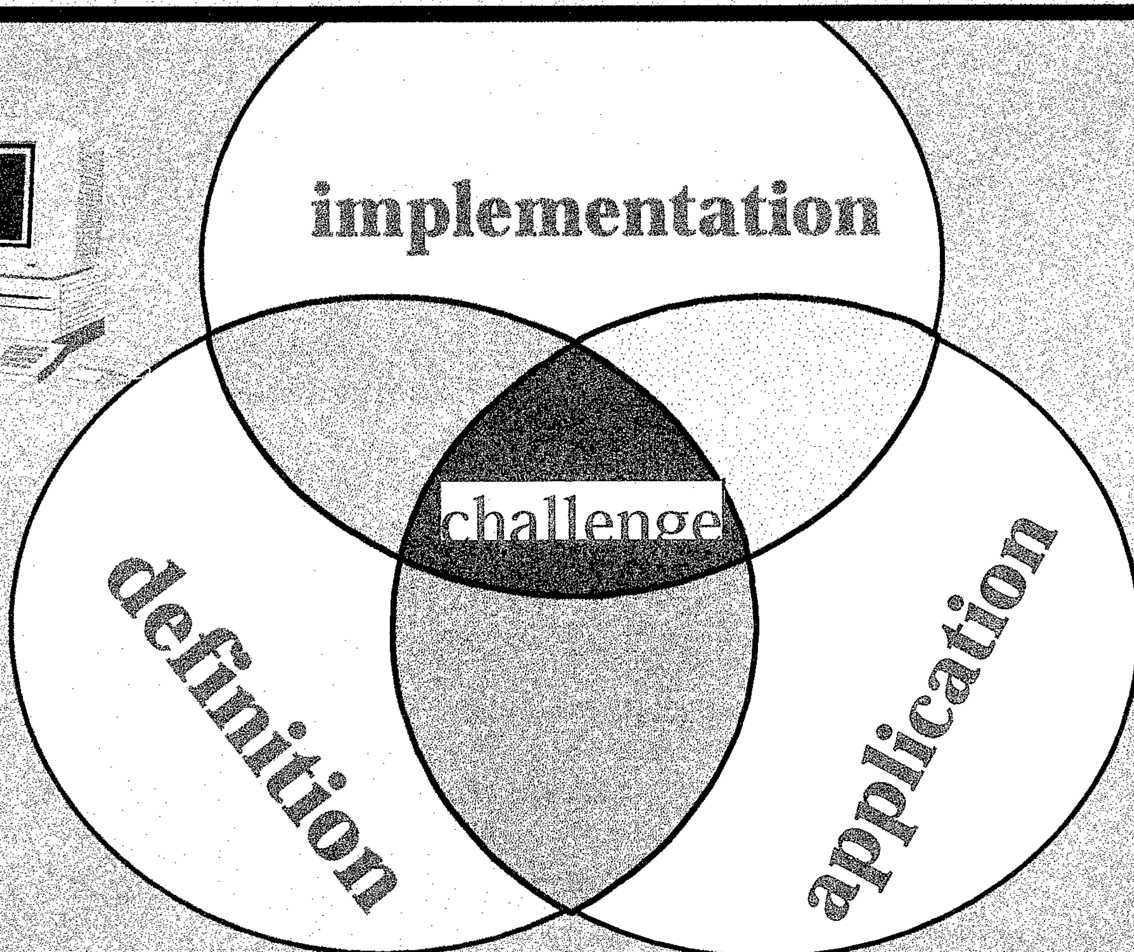
PEOPLE-PROCESS-TECHNOLOGY

- EXPERTISE plus partners
- methodologies/documentation
- tools

•BALANCE

QUESTIONS?





The **SIMULATION** *CHALLENGE*

- the challenge
- a process of handling the challenge
- technology employed or needed
- process-people-technology relationship

The CHALLENGE

- not unique to System Integration Labs (SILs)
- three aspects: 1) **acquisition of information**
  2) **implementation of process**
  3) **retention & dissemination**
- Adequate simulation is highly sought after

IDEAL versus Reality

IDEAL	Reality
• complete information & requirements	• incomplete & often changing
• perfect management, manipulation & use	• cost & resource constraints
• right quantity, absolute technical accuracy, and perfect utility	• platform variations & capabilities/limitations

The 4 C's

- **Constraints** -- schedule, resource, cost
- **Complexity** -- requirements through dissemination
- **Components** -- expertise, methods, technology tools, partnerships
- **Criticality** -- "**prime time**" **warfighter support**

PROCESS

- Definition phase
- Implementation phase
- Application phase

TECHNOLOGY

- SIMULATORS
- DATABASE TOOLS
- "AUTOMATION"

PEOPLE-PROCESS-TECHNOLOGY

- EXPERTISE plus partners
- methodologies/documentation
- tools

- **BALANCE**

The SOS Track

- **Wednesday afternoon thru Friday Morning**
- **Concurrent OBSCURANT Track Thursday**
- **Program -- spectrum of simulation, mission environments, and T&E**

SIMULATION Working Group Session

- Informal discussion
- Issue Identification
- Possible Solutions
- **SIMULATION & SENSOR CHALLENGES**
- **CHANGING SUPPORT CONCEPTS**

ISSUE

- Support concepts -- **What is known about "latest" initiatives and whom? Policy makers, developers, implementers, intended users, testers, acquisition decision makers**

ISSUE

- **SIMULATION development**
- **SIMULATION follow-on support**
- **Rapid reprogramming of simulation in T&E and training / mission rehearsal**

ISSUE

- Simulation/Simulator/Test Tools update:
  COTS / legacy / hybrid / open systems

The SIX PILLARS of the Avionics and Weapons Systems Test Process

- **Modeling & Simulation (M&S)**
- System Integration Laboratory (SIL)
- Hardware-in-the-Loop (HITL)
- Installed Systems Test Facility (ISTF)
- Open Air Range (OAR)
- Measurement facility

TEST PROCESS

- **GOALS:** 1) **Provide accurate and useful data**
  2) **Assist in shortening the acquisition cycle of weapon systems**
  3) **Invoke more discipline into the testing**
  4) **Make use of technology (M&S)**

TEST PROCESS

Decision Steps

- Identify required information (step 1)
- Research Development & Acquisition activities
- Combine T&E and other assessments (step 5)

Evaluation Steps

- Pre-test analysis (step 2) -- Major objectives & expected results
- Planning & Conduct (step 3) -- measured results
- Post Test Synthesis & Evaluation (step 4) -- feedback

TEST PROCESS

Theory

- Six defined categories of test resources
- Solve acquisition problems through defined PROCESSES & TECHNOLOGY

Implementation

- Reality depends on service interpretation & implementation and fiscal/political factors
- Progress has been made but is complex problem

AIRBORNE ASW ACOUSTIC SENSORS

JOINT SERVICE AVIONICS
BRIEFING TO INDUSTRY
17,18 JUNE 1998

Michael T. Junod
NAWC AD 4.5.5.4.1
(301)-342-2131
(301)-342-2098 (fax)
junod_michael%pax6a@mr.nawcad.navy.mil

DOD TAP Structure

- Air Platforms
- CB Defense and Nuclear
- Info Systems and Tech
- Ground Vehicles and Watercraft
- Materials and Processes
- Biomedical
- Sensors and Electronics
- Space Platforms
- Human Systems
- Weapons

Sensors, Electronics, and Battlespace Environment TAP Structure

- Radar Sensors
- Electro-Optic Sensors
- Acoustic Sensors
- Automatic Target Recognition
- Integrated Platform Electronics
- RF Components
- Electro-Optics Technology
- Microelectronics
- Electronic Materials
- Electronics Integration Technology
- Terrestrial Environment
- Ocean Battlespace Environment
- Lower Atmosphere Environment
- Space / Upper Atmosphere Environment

Acoustic, Magnetic, & Seismic (AM&S) Sensors Scope

- **Develop Acoustic, Magnetic, and Seismic Sensor Technologies To:**
  - Detect, Classify, Track, and Localize Targets in the Battlespace
    - » increase resolution and dynamic range
    - » improve target detection and classification in cluttered environments
    - » classify and localize faster and more accurately
  - Decrease sensor volume and weight
  - Improve affordability

Why Air ASW

- Air has a Major Role in ASW
  - Global Rapid Response
  - Flexible and Adaptable to Changing Tasking
  - Highest Search Rate
  - Multi-Mission ASW (Surveillance to Attack)
  - Operates "Out of the Submarine's Sphere of Influence"
  - Joint or Independent OPS
  - Exploits Multiple Phenomenology
- New S&T Important to Optimize Air ASW Capabilities

Key Littoral ASW Needs

- Survivable, reliable, joint-capable C4I system architecture
- Detailed and thorough knowledge of battlespace environment
- Cueing sensors that can provide rapid initial detection anywhere in a large area
- Increased reliance on active sonar, multi-static active systems, and non-acoustic sensors
- Detection and localization sensors that enable successful prosecution
- Diversified portfolio of assets that provide rapid and continuous response to threats
- Weapons that can deliver a rapid, decisive response

REFERENCES:

1. Littoral anti-submarine warfare concept, naval doctrine command, 16 June 1997
2. 1997 ASW focus statement, OPNAV
3. 1997 ASW assessment, OPNAV N84, 10 April 1997
4. 1997 Science and technology requirements, N091 & ONR, 31 July 1997

Collocation of ASW Assets

Need Picture

"ASW Alley"

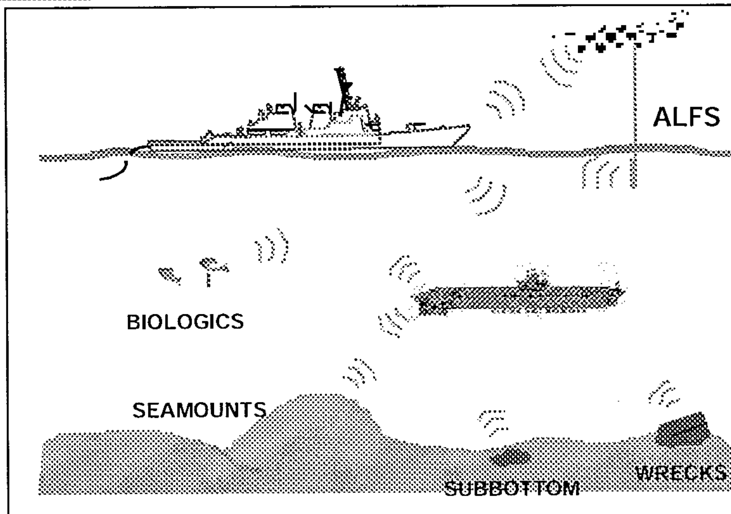
- VX-1 Operational Test & Tactics Development
- Platform & Sensor Development Test Teams
- Sensor S&T Research and Development Teams
- TSC Life Cycle Support
- METOC
- PEO (A) Acquisition Teams
- So. Lab Complex (1.0 mil)

1010

Air ASW Acoustic Sensors
6.2 Programs

- AACD
  (ALFS Active Classification Development)
- Environmentally Adaptive Active Classification for Impulsive Source Sonars
- Airborne Rapidly Deployable Technology
- PADS (Parametric Airborne Dipping Sonar)
- Air ASW Surviellance

AACD
(ALFS Active Classification Development)



NAVY NEED

- Improved active detection and classification capability against conventional subs in shallow water

PROJECT OBJECTIVE/EXPECTED PAYOFF

- TRANSITIONof an Computer automated / operator aided active classification capability (sub / non-sub) for ALFS [1]
- Detection of low target strength, low Doppler submarines in high clutter shallow water environments [1]
- Frequency band selection for interoperability to prevent mutual interference and enable bistatic operation with AN/SQS-53 and TARS

TECHNICAL ISSUES

- Definition and implementation of interoperability and bistatics
- Collection of sufficient data for tuning and evaluation
- Applicability of algorithms to ALFS sensor
- Similarity of MUF array and ALFS data

MILESTONES

- FY97
  - Complete ALFS MAST data Interface
  - Build NAWC MAST processor clone
  - Collect Significant quantities of ALFS Data
- FY98
  - Algorithm Applicability Analysis/definitions
  - Implement ALFS functionality in FBL
  - Collect ALFS data
- FY99
  - Tune & evaluate FBL
  - Transition technology to ALFS system sponsor

[1] Operational requirements document for ALFS, ORD No. 295-05-92

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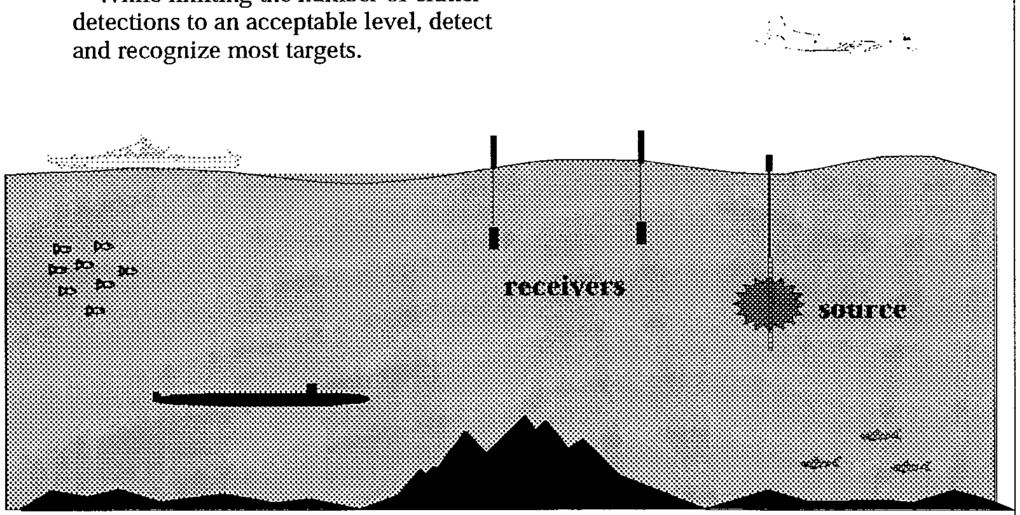
Environmentally Adaptive Active Classification for Impulsive Source Sonars

PROBLEM OVERVIEW

* While limiting the number of clutter detections to an acceptable level, detect and recognize most targets.



ISSUES

- The number of non-target detections per ping, i.e., clutter detections, can be more than a human operator can handle.
- The sources of clutter detections vary from one environment to another.
- The significant effect of ocean propagation on the observed echoes is not well understood and varies considerably from one ocean environment to another.

OBJECTIVE

To develop *automatic detection and classification* algorithms that can detect *most* target echoes while limiting the clutter (non-target) detections per ping to a number that the sonar operator can handle.

MILESTONES

FY97
- Characterize *noise* and *signal+noise* waveforms from all available sea tests.
- Extend and interpret real-data observations with acoustic modeling.
- Set energy detector and target-class parameters using historical data and model predictions.
- Develop and test classifier whose clutter parameters are updated after each ping.

FY98
- Investigate several spatio-temporal algorithms for clustering detections.
- Use combination of historical data, *in situ* measurements and modeling to set target-class parameters for classifier.
- Investigate several ways to preprocess detections prior to classification to mitigate medium effects.

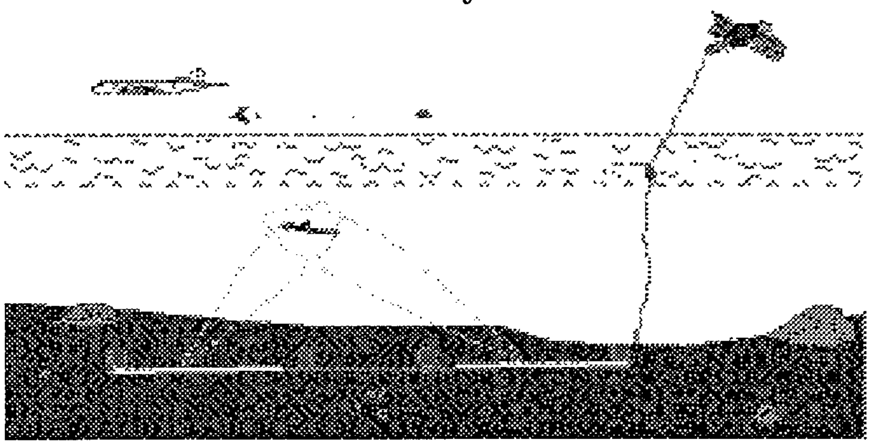
FY99
- Determine best overall detector and classifier design, and carefully quantify its performance.

Airborne Rapidly Deployable Technology

NAVAL AIR WARFARE CENTER

AIR DEPLOYABLE SYSTEM CONCEPTS

Air-Launched Glider-Deployed Sensor Systems



ISSUES

- COMMANDABLE GPS GUIDANCE
- ARRAY DEPLOYMENT GEOMETRY
- COMPACT LOW POWER, HIGH PERFORMANCE FIBER OPTIC NETWORK ARRAY DESIGN

TRANSITION

- ADVANCED DEPLOYABLE SYSTEM (ADS)
- MERLIN, SONOBUOYS, OTHER ASW SENSORS
- OCEANOGRAPHIC SENSORS

OBJECTIVES

- DEVELOP AIRBORNE DELIVERY AND DEPLOYMENT CAPABILITY FOR AUTOMOMOUS ASW ARRAYS AND SENSORS IN LITTORAL WATERS

PAYOFFS

- RAPID SURVEILLANCE CAPABILITY IN REMOTE, HOSTILE REGIONAL CONFLICT AREAS
- RAPID DEPLOYMENT (<24 HR RESPONSE, <1 HR DEPLOY
- STANDOFF CAPABILITY
- REDUCED AIRCRAFT VULNERABILITY
- FORCE MULTIPLICATION WITH AUTONOMOUS OPERATION

MILESTONES

FY-96
- SCALE MODEL GLIDER DESIGN/DEVELOPMENT
- RAPID ARRAY DEPLOYMENT TEST/MODEL

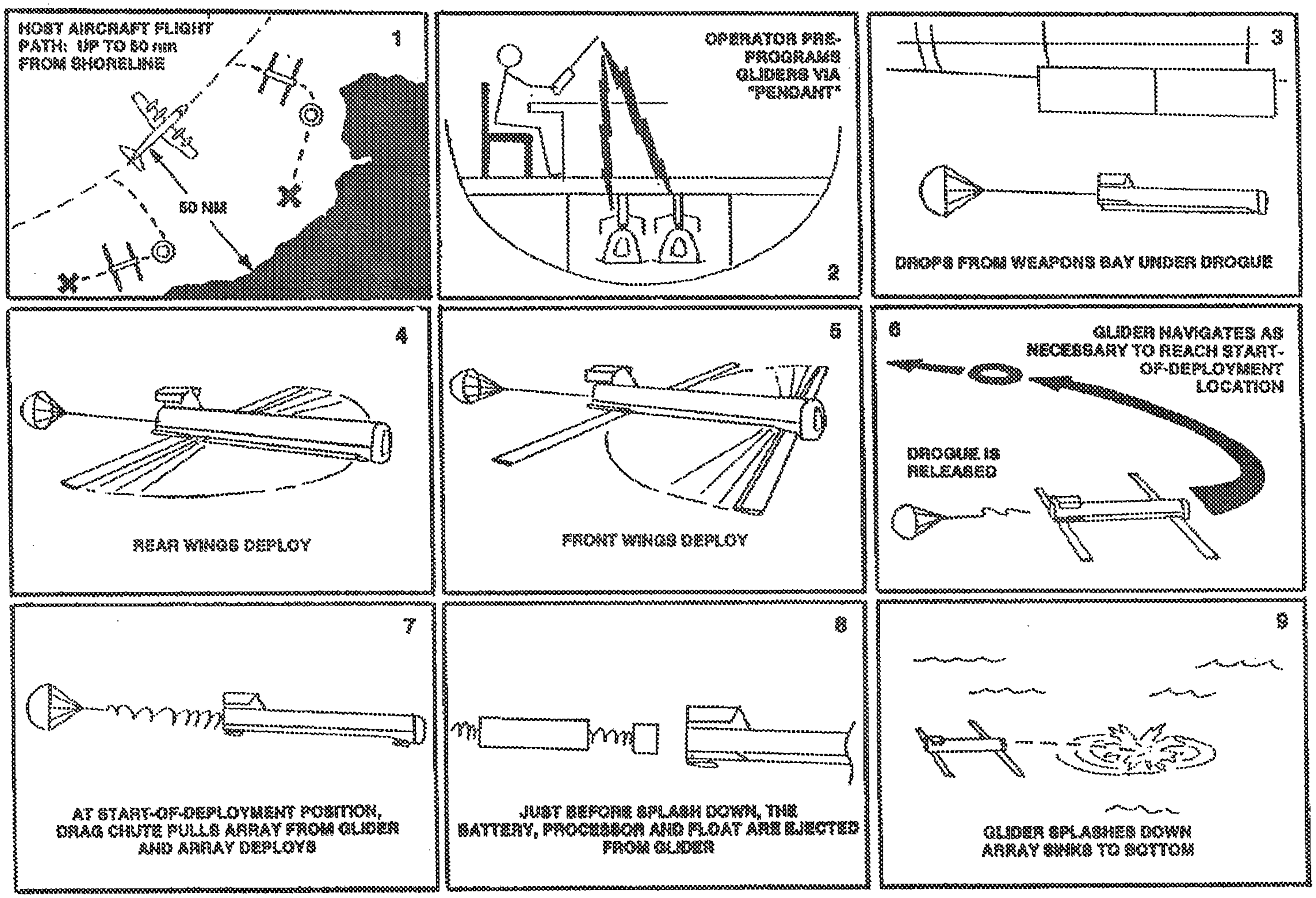
FY-97
- COMPLETE QUARTER-SCALE GLIDER DEVELOPMENT
- INITIATE FULL-SCALE PROTOTYPE DEVELOPMENT

FY-98
- FULL-SCALE PROTOTYPE GLIDER DEVELOPMENT

FY-99
- GLIDER PROTOTYPE FLIGHT TEST
- GLIDER DEPLOYMENT OF TEST ARRAY

FY-00
- FULLY INSTRUMENTED ARRAY COMPLETE
- DEMONSTRATION TEST OF GLIDER AND INSTRUMENTED ARRAY AT SEA

X - Glider
Deployment Sequence



FULL SCALE PAYLOAD

WEIGHT - 250 LBS LENGTH - 100 IN DIAMETER - 11.25 IN

Air ASW Surveillance

- **New ONR Sponsored Initiative**
  - Four year effort to develop in-buoy signal processing technologies that allow wide area acoustic undersea surveillance and search from air-deployed drifting sonobuoys/arrays
- **Initial Approach**
  - In-Buoy processing for advanced ADAR or HLA
    - » Active multistatic automatic detection and classification
    - » incoherent and coherent sources
- **BAA**
  - Announcement in CBD by next week
  - 2 phase development
    - » Phase 1 - four month feasibility phase
    - » Phase 2 - two to four year execution phase
  - 5 to 10 page proposals due 31 July
  - Finalists will be invited to workshop @ Pax to brief proposals
  - Awardees will be selected after Workshop - Work to Begin 1 Oct 98
- **POC**
  - Dr David Bromley, NAWC AD 4.5.5.4.1
  - (301)-342-2116; bromleydw%am7@mr.nawcad.navy.mil

Air ASW Acoustic Sensors 6.3+ Programs

- LWAD (Littoral Water Advanced Development)
- ALFS (Advanced Low Frequency Sonar)
- NetTORP (Networked Torpedo)
- Distant Thunder
- EER/IEER/AEER (Extended Echo Ranging, Improved, Advanced)
- SWALAS (Shallow Water ASW Localization and Attack System)

LWAD

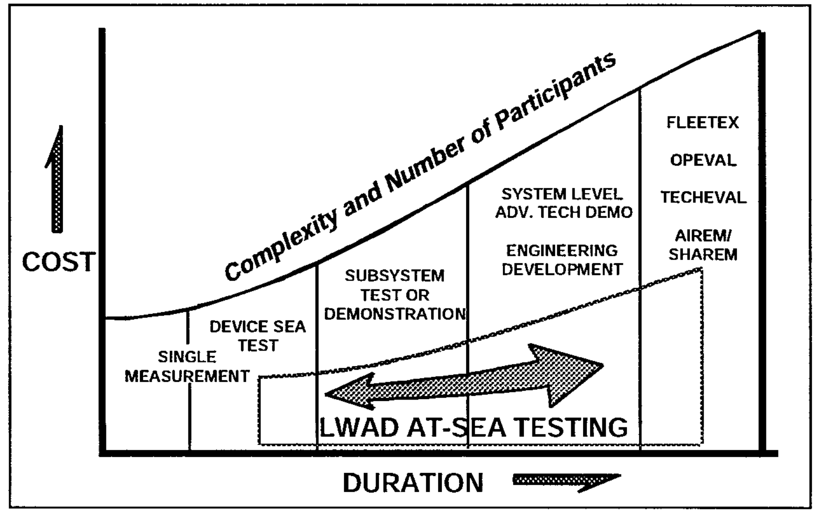
Mission

Provide an affordable sea test program in littoral environments that will enable the transition of advanced USW technologies to higher acquisition category programs.

Project Objectives

- Focus on the littoral undersea battlespace
- Address prioritized fleet and technical issues
- Break across traditional organizational barriers
- Target S&T emerging and operational systems
- Optimize use of people, funds, and assets
- Risk Reduction as identified by customers
- Commit to the transition

Spectrum of At-Sea Testing



Special Features

- Experienced Core Sea Test Team (7 Sea Tests/40 projects/2.5 years)
- Direct access to Laboratory, Academic and Industry research assets
- Cross-platform sea test integration

Advisory Board Members

Organization	Codes
ONR	32
CNO	N096, N84, N85, N86, N87, N88, N911
DASN	M/UW
DARPA	TTO
NAVSEA	PMS 403, PMS 411, PMS 425, ASTO
NAVAIR	PMA 264, PMA 290, PMA 299
SPAWAR	PD18

12 June, 1998

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LWAD

LWAD PROCESS

Notional At-Sea Testing Scenarios

- **I USW Systems Interoperability**
- **II Tactical Exploitation of the Littoral Environment**
- **III Advanced Active Sensors**
- **VI Advanced Passive Sensors**
- **V Detection of Mines, Obstacles, and Minisubs in the Littoral Environment**
- **VI Non-Acoustic USW**
- **VII Network Centric USW**

Participants Provide

- Funded programs with well-defined S&T product needing to be tested at sea
- Sea Test Plan inputs and participation
- Funded analysis plan
- Mobilization and demobilization support
- Environmental compliance documentation (if required)
- PI at sea

LWAD Provides

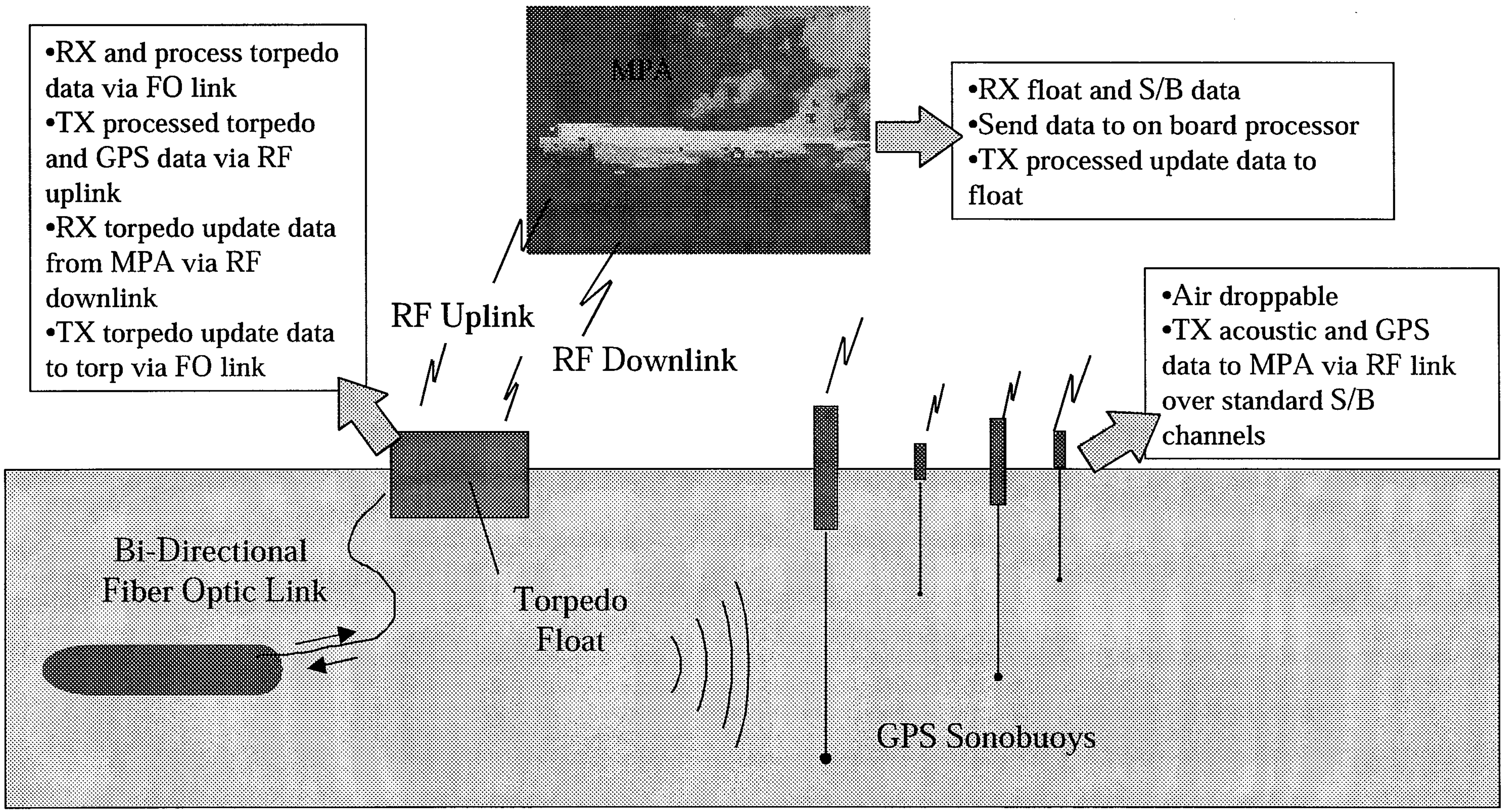
- Research platforms (air, surface, subsurface)
- Fleet asset scheduling (TEIN K1525)
- Environmental characterization
- Integrated sea test planning process
- Mobilization and demobilization oversight
- Chief Scientist, Test Director and Unit Coordinators execute the sea test
- *In situ* data collection for test reconstruction
- Marine Mammal Mitigation procedures for environmental compliance

Products/Deliverables

LWAD
- Environmental Characterizations
- Integrated Sea Test Plan
- Test Reconstruction Dataset
- Quicklook Report (30 days)
- Sea Test Summary Report (8 months)

Participants
- Quicklook Report (input)
- Sea Test Summary Report (input)
- Technical analysis report/dataset/algorithm

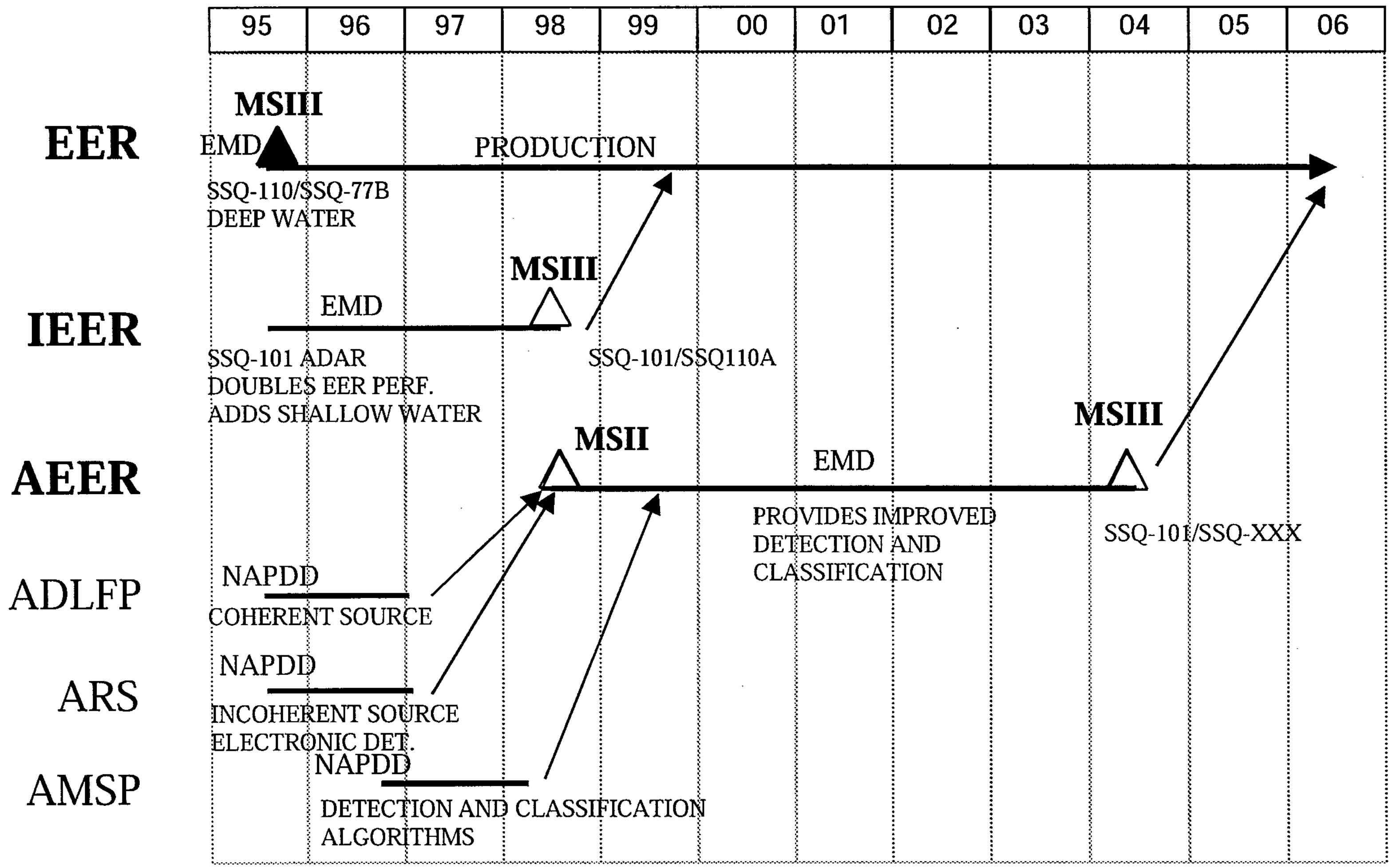
NetTORP (Networked Torpedo)



Air Acoustic Active Systems

	SEARCH			LOCALIZATION
	EER	**IEER**	**AEER**	**SWALAS**
Operating Areas	Deep	Deep/Shallow	Deep/Shallow	Deep/Shallow
Lead Platform	P-3	S-3	P-3	P-3
Source	110 (A) (B)	110(A) (B)	Electroacoustic	Free Flooded Ring Projector Array
Receiver	SSQ 77B	SSQ 101(ADAR)	SSQ 101(ADAR)	Horizontal Planar Array
Classifier (Features)	Seq. Rule Based (6) -----(7)	MVG (13)	Under development	TBD
Display	Full A-scan	BVT, A-scan	Under development snippets	Current DICASS Display
Processing	8 Directionals 10 OMNI	4 ADAR Arrays	TBD	IBSP (DICASS Compatible)

EER ROAD MAP



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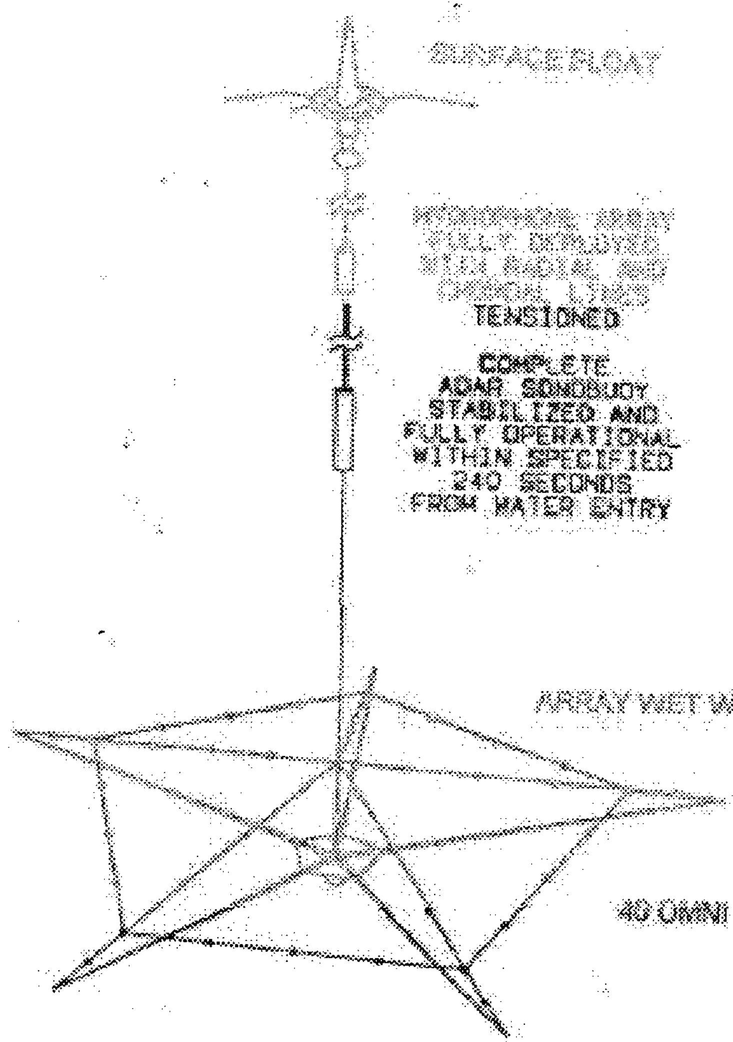
AN/SSQ-101 (ADAR)



OPERATIONAL DEPTHS = 20, 90, or 150 m

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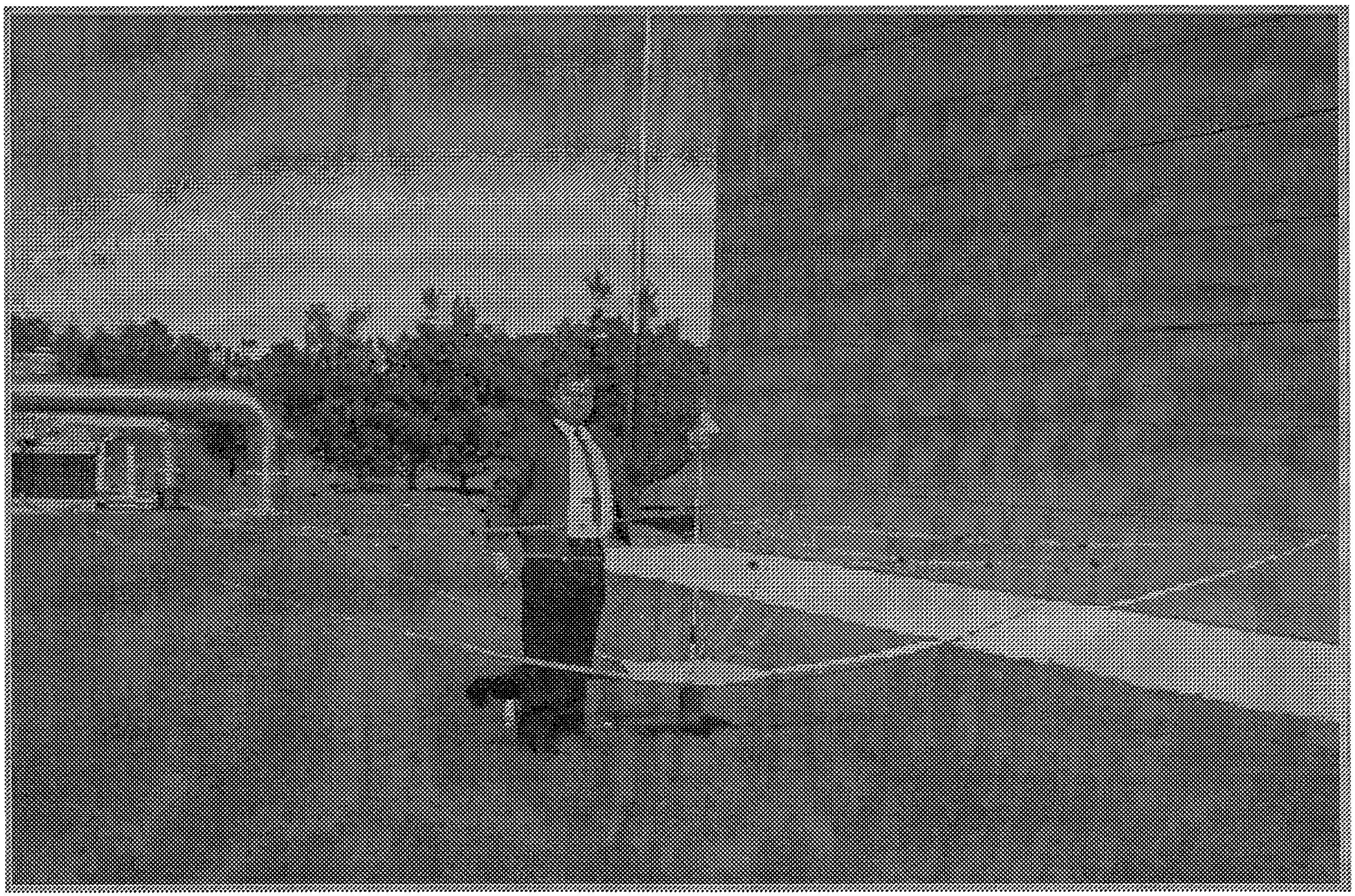
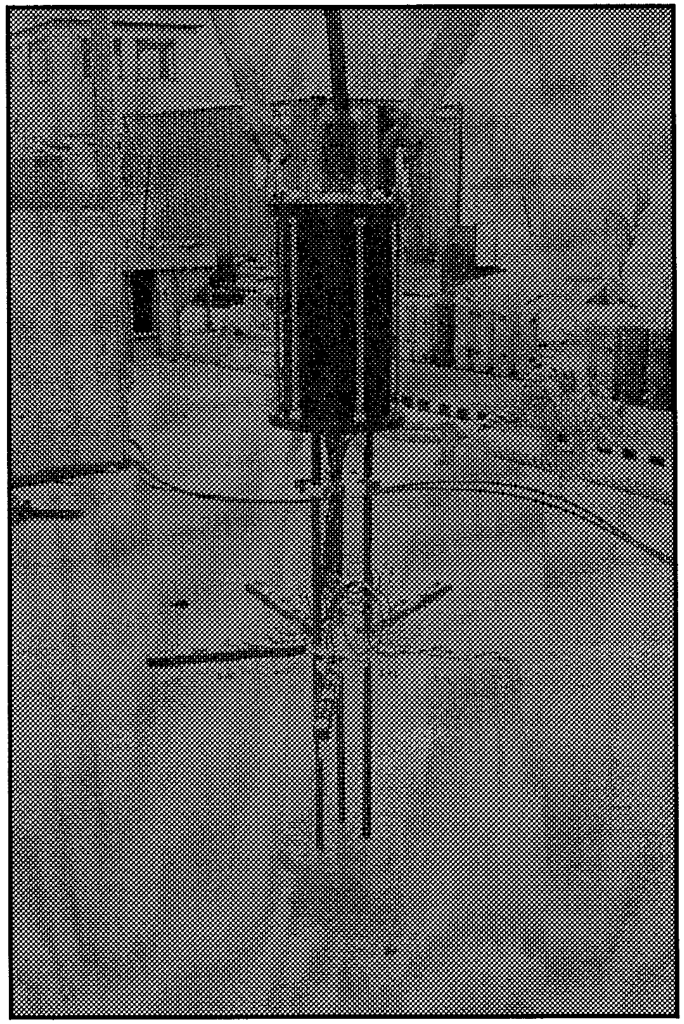
SSQ-101 (ADAR)



SWALAS Receive Array



Air ASW In The 21st Century

- Conducted Primarily in the Littorals With Some Deep Water Operation
- Highly Integrated Operations
- Minimal Availability of Traditional Cueing Systems
- Operating Areas will be Inside Contested Waters
- Automation to Offload Operator Workload

Overarching Concepts

Today

- DIFAR
- Extended Echo Ranging (EER)
- Air Deployed Acoustic Receiver (ADAR)
- Laser Radar (LIDAR)
- Low Grazing Angle Periscope Detection Radar (PDR)
- Magnetic Anomaly Detection (MAD)
- Directional Commandable Active Search System (DICASS)

Tomorrow

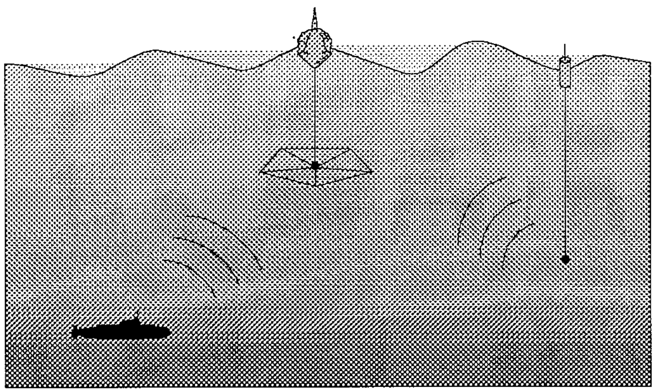
- AEER
- Shallow Water Airborne Localization and Attack System (SWALAS)
- High Altitude PDR

2010

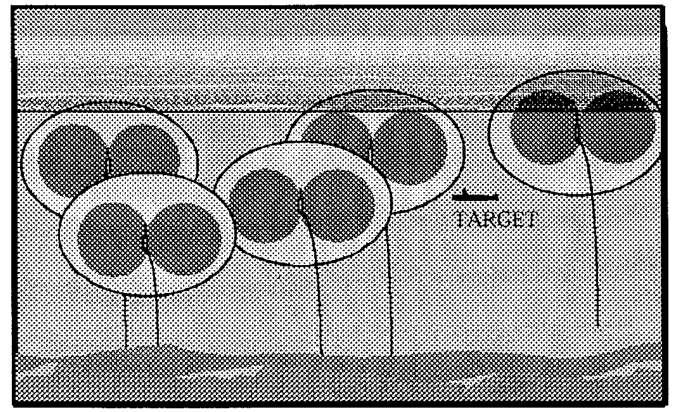
- Long Life Surveillance & Search System
- Ubiquitous multi-statics
- Rapid Automated Battle Space Awareness
- Platform Fully Integrated into Network Centric C4I
- Standoff Using Glide Sensor & UAVs
- Value Added Sensor Phenomenology
- Enhanced Training & Operator Proficiency
- Precision Localization & Attack
- Deep Water Surveillance
- Airborne Rapid Environmental Sensing
- Enhanced System Capabilities using
  - Modularity
  - COTS/NDI
  - Automation

ACOUSTIC R&D TECHNOLOGY CONCEPTS

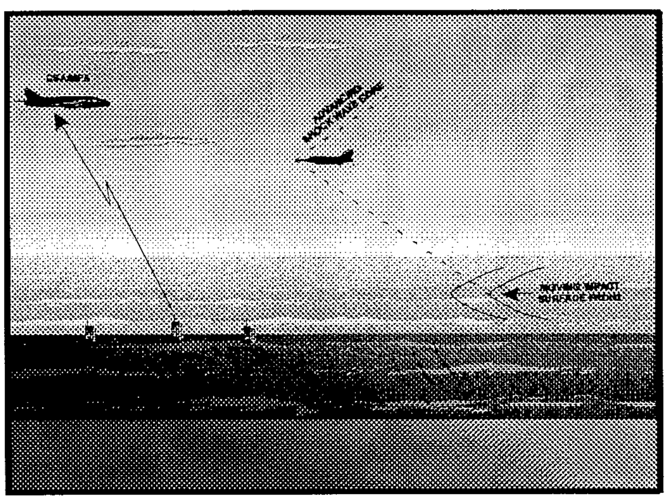
SMART High Performance Acoustic Receiver (ADAR+)



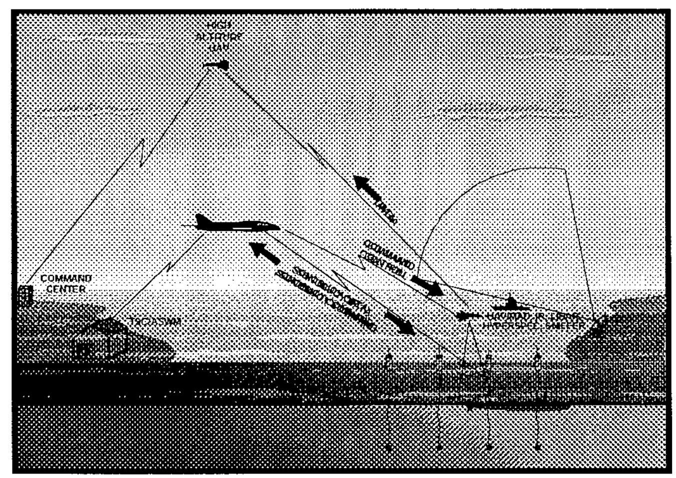
Shallow Water Deployed Reconnaissance Multi-Sensor (SWARM)



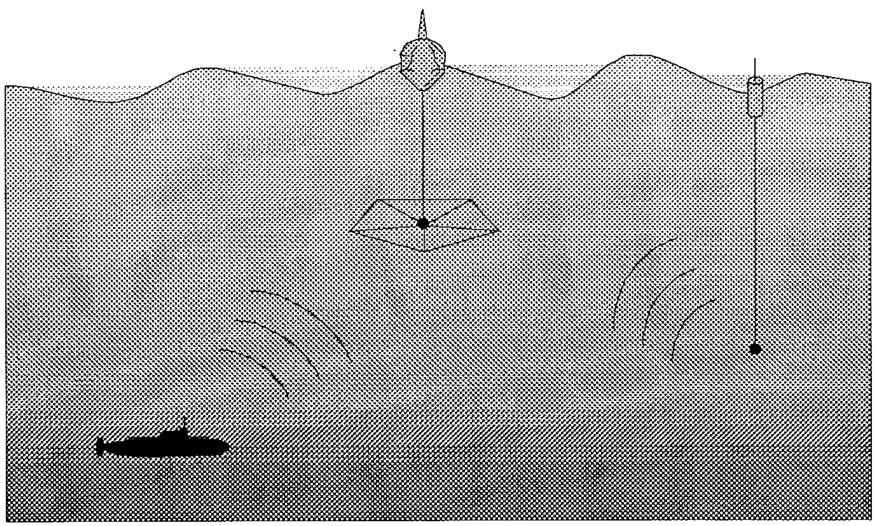
Stand Off ASW



Multi-Sensor ASW UAV



Super ADAR



Features

- GPS
- In Buoy Processing
  - Screeners in Buoy
  - Only Screened Signals Sent to Aircraft
  - Background Passive
    - -- Screen for C2 Cavitation
    - -- HF Fathometer
    - -- LF BB (Planar Array Difar)
- ABF (SBIR)
- Efficient Digital Code
  - -- Error Correction
  - -- Compressed Data
- Command Full Up Direct Ops (Limited BW)/ Command Limited Constant Look Beams

Advantages/Payoffs

- In Buoy Screeners, Use Full BW
- Full BW Screened Signals Sent to Operator
- Reduced RF BW
- Reduced Transmission Time/Reduced Battery Required
- Reduced Operator Workload

Issues

- Transmit Packet Design
  - Beams? Number?
  - Length of Snippet?
- Screener (Wayland, PBN, Other)
- Background Passive Algorithms
- Adapt Modem Technology to RF Links

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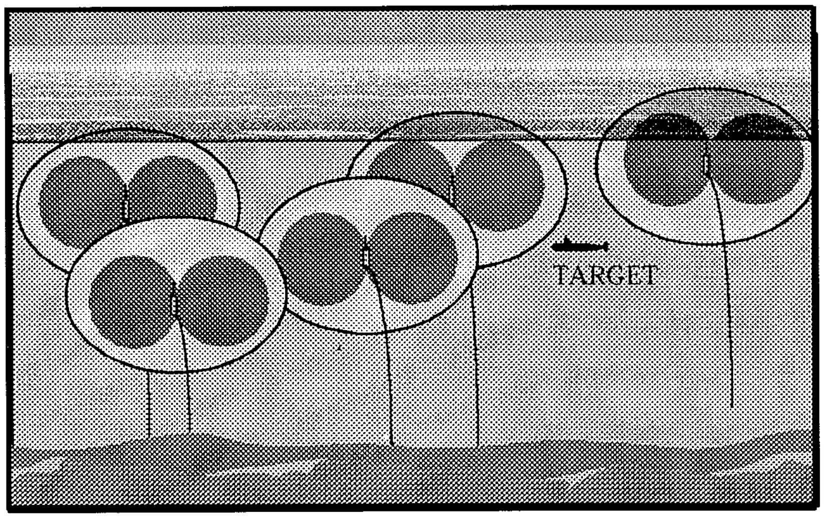
Shallow Water Air Deployed Reconnaissance Multisensor (SWARM)



Objectives and Description

- Observe submarine transits over zone
- Covert deployment and operation
- Unattended operation for days or more
- Numerous cheap proximity sensors
- "A" size (can be glided into place)
- Multi-influence confident auto alerts
- Expose & transmit only when triggered

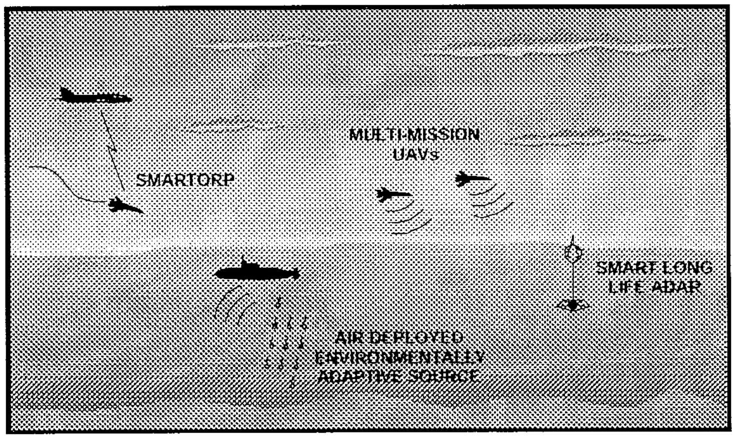
Technologies

- Exploit vertical B vs. horizontal E fields
- Noise, motion & verticality effects
- Ranges, correlations & signatures
- Composite ELFE, Difar with IBSP
- Trial algorithms with reliable features:
  - ELFE, Pressure, C2 & other AIS
- Dual buoyancy bobbing taut line moor
- Field integrity modeling

Advantages and Issues

- Passive except for RF reporting
- Sensors quickly deployable by air
- Near real time reporting; good fixes
- No operator other than tactical viewer
- Provides peacetime or wartime cueing
- Low bandwidth reports easily relayed
- Depth affects bobbing & mooring
- Current affects sensor useful life

Stand Off ASW



Components

- Glide Sensors
- Smart Long Life ADAR
- Air Deployed Long Life, Environmentally Adaptive Active Source
- SMARTORP/NETSTAT
- UAV Mounted Sensors

Technologies

- Data Links
- Data Compression
- Delivery Concepts
- UAV Mounted Sensors
- Stealth/LO UAVs

Issues

- Aircraft On Board Sensor Capabilities
- Low Cost/Lightweight/Low Power Sensors for UAV
  - Radar
  - IR
  - Sniffer
  - MAD
  - Hyperspectrum
- Glider Guidance and Control (Sensor and Weapon)
- UAV Range/Endurance

Air ASW
S&T/R&D Thrusts

Sensors

- Super ADAR
- Shallow Water Air Deployed Reconnaissance Multi-sensor (SWARM)
- High Altitude PDR for Mast & Wake Detection
- Steerable RADAR
- Digital MAD
- Laser & EO Sensors
- Environmental Probes

Processing

- Smart FS
- Universal Adaptive Processor (COTS/MSSIP/PC Spin-offs)
- Autonomous Detection Algorithms & Classification
- Personal Assistant
- Non-Linear Processing
- Neural Nets
- In-Buoy Processing

Sources

- Long Life Air Deployed Source
- Environmentally Adaptive Directional Source (EADS)
- Supersonic Shock Source (S4)
- Green Source

Sonobuoy Technology

- Deployment Mechanisms
- GLIDE Mechanisms (Strap On)
- GPS/Inertial Tracking System
- Energy Sources (Batteries)
- Efficient Electronics

Air ASW
S&T/R&D Thrusts (Cont'd)

New P^3I Platforms

- Multi-Sensor ASW UAV (UAV MAD)
- Uninhabited Combat Air Vehicle (UCAV)
- Common Support Aircraft (CSA)
- ALFS/ADAR

C^4I

- Multi-Sensor/Platform Information Fusion for ASW (Fuzzy Logic/Correlation)
- Enhanced Telemetering (Data Link & GPS)
- Embedded Training
- Air Launched Real World Training, Stimulation and Simulation

Conclusions

- Air has a Major Role in ASW
- Littoral ASW will drive the direction for new airborne ASW systems development
- NAWC has developed an Air ASW system strategy
- Current ASW situation requires unified approach between platform and sensors supported by strong ASW leadership
- NAWC has initiated focused conceptual approaches
- Revolutionary technology thrusts are required while leveraging off existing system development programs
- Patuxent River complex provides a unique opportunity to facilitate this strategy

NAVAL AVIATION SYSTEMS
TEAM

NAVAL AIR SYSTEMS COMMAND
RESEARCH & ENGINEERING

Software Technology Briefing To Industry

John Walker
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Agenda

- Changing Roles
- Current Challenges
- Sources for Solutions
- On Going Efforts
- Summary

Changing Roles

Before, Our Funding Provided Leadership

- Program office budgets through task leader budgets could accommodate software technology research and insertion
- All levels of the Organization were funding research into local problems
- Research was done by organic personnel
- Small hard problems were solved, Point solutions were developed

Budgets Becoming Smaller and smaller

- Funding transitioning from Long Term research to Short Terms product focused tasks
- Funding is controlled at a higher level
- Technology is being pushed down and across the organization

Now, Our Leadership Will Provide Funding

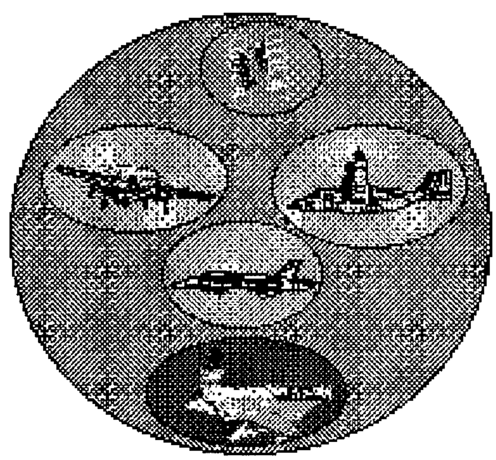
- Competition for funds is open and fierce
- Research needs to have a Navy Product Focus
- Research needs to have broad DoD/Industry Application
- Solve hard general problems and develop general solutions

Current Challenges

- System of Systems
  - Network Centric Warfare
- Maintenance of Complex Software Systems
- Development of Complex Software Systems

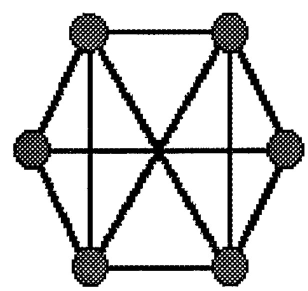
System of Systems

- Interdependent Systems vary from platform to code module in scale
- Systems going to COTS and GOTS
- Primes Lead Development



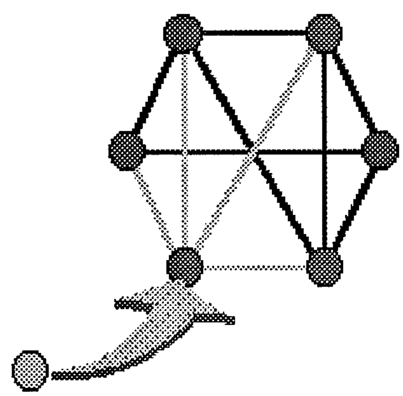
Integration of Integrations

- Increase functionality and effectiveness of System of Systems without adding systems
- Apply Data Resources to any system from any system



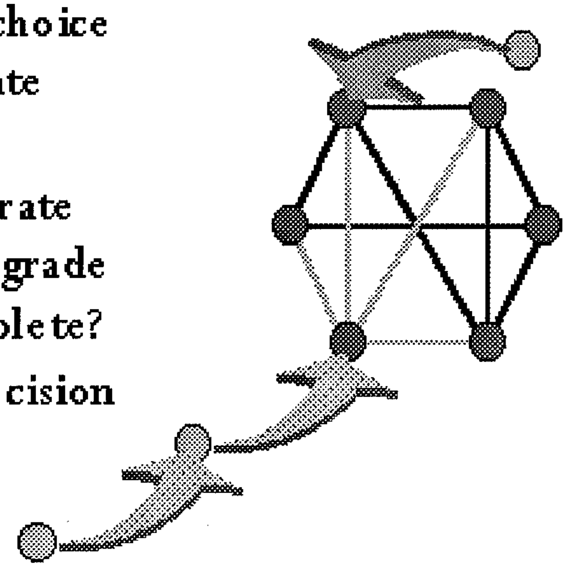
Continuous Integration of Integrations

- Commercial End Of Life
- New Open Standards
- New Systems
- New Integrations



Real-time Continuous Integration of Integrations

- We have no choice but to integrate upgrades
- Can we integrate before the upgrade becomes obsolete?
- DoD only Decision



Maintenance of Complex Software Systems

- **What The Programs Will Soon Require**
  - Modification of complex software systems by personnel with little or no experience who must rely solely on new technology to succeed
  - Modifications made relatively overnight and free as compared to full-scale development effort
- **Do we have any silver bullets?**
  - No, but we are collecting some of the pieces

Development of Complex Software Systems

- Decrease Cycle Time
  - Field prototypes
- Modify Development Process To Decrease Life Cycle Costs
  - No affect to development costs
- Distributed Development
  - Decrease Cycle Time and Increase Reliability

Sources For Solutions

- People
- Resources
- Money

People

- People to think of the solutions
- People to convey the solutions to the funding sources
- People to realize the solutions
- Teams from DoD, Industry and Academia work the best
- Software Technology is NOT institutionally funded at NAVAIR

Resources

- Advanced Software Technology Laboratory
- Develop Memorandums of Understandings and Cooperative Agreements to share resources with Academia and Industry

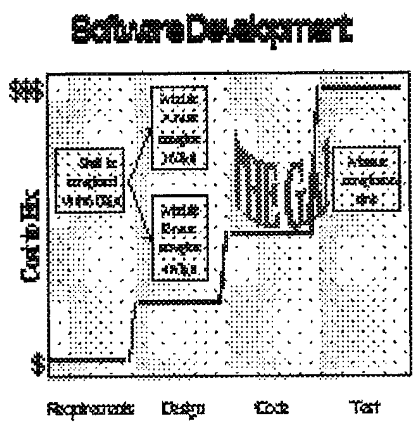
Money

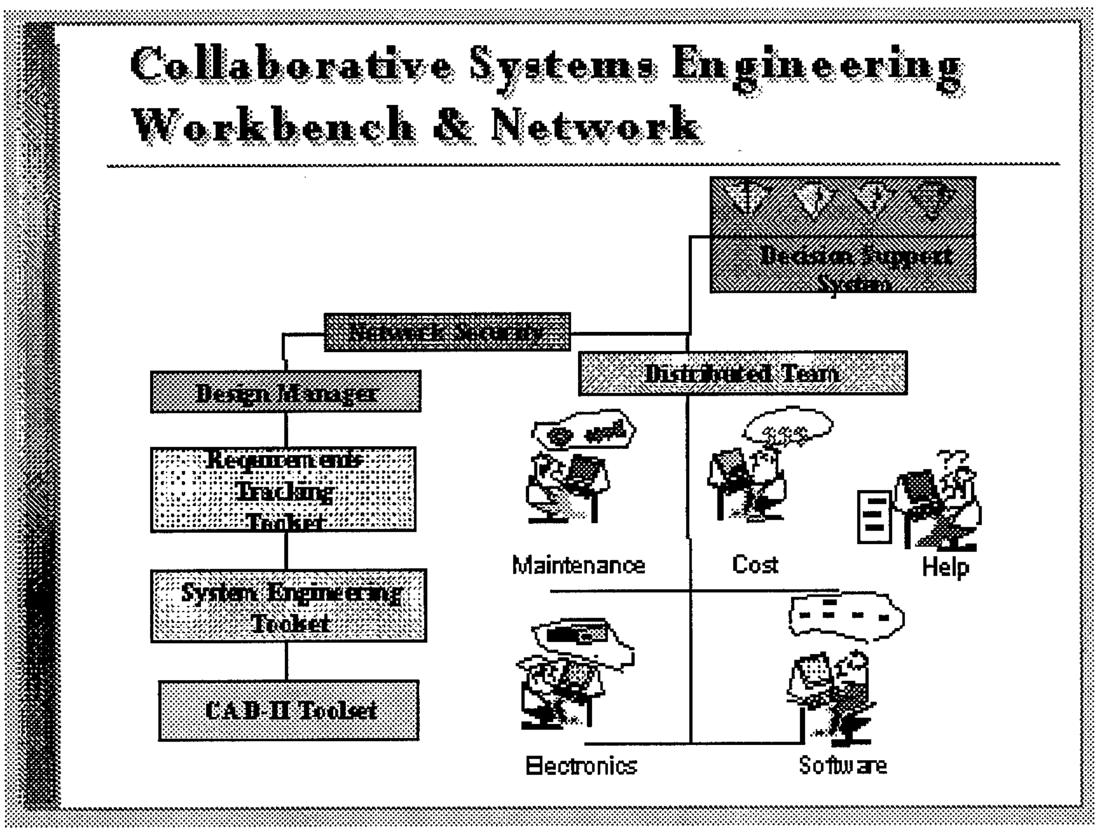
- Direct Project Funding
- Small Business Innovation Research Program (SBIR)
- Corporate Investment Program
- Bid and Proposal B&P
- Office of Naval Research
- DARPA, NSF, Other Laboratories

On Going Efforts

TEMPUS

- Software Metric to predict throughput in design and coding phase
- Fills the gap between throughput budgets allocated in the requirements phase and measured throughput in the integration phase




Collaborative Systems Engineering Workbench & Network
Decision Support System
Network Security
Design Manager
Requirements Tracking Toolset
System Engineering Toolset
CAD-II Toolset
Distributed Team
Maintenance
Cost
Help
Electronics
Software

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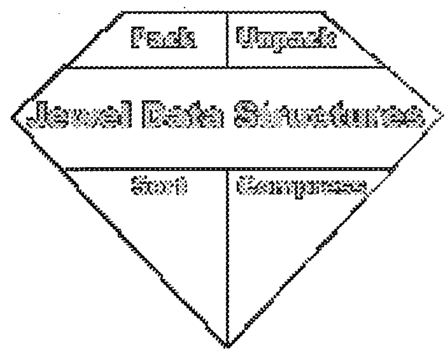
Jewel Compression

- Smart algorithm to capture, index and store continuous execution path data from real time software systems.
- Creates a database of how the system actually works while it is operating



Summary

- **Money for small hard local problems is gone and money for large general problems is hard to get**
  - System of Systems - Network Centric
  - Maintenance and development of complex software systems
- **We need to work together**
  - Share ideas, people, resources

NAVAL AVIATION SYSTEMS TEAM

NAVAL AIR SYSTEMS COMMAND

RESEARCH & ENGINEERING

AVIONICS DEPARTMENT

C4ISR&T AVIONICS

JAWS Conference
18 June 1998

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C4ISR&T Challenges

- Evolving Warfighting Environment
- Evolving Acquisition Environment
- Evolving Requirements for C4ISR&T

4.5 Avionics

Warfighting Environment

- Wide range of adversary types
  - Enemy more Mobile, Asymmetric, with Non-linear Operations
- Own forces -- Joint, Allied, Coalition
  - Rapid projection, Mobile, Flexible
- Sensor-to-Shooter response requirements
- Identification requirement -- "CNN" Factor

Acquisition Environment

- Streamlining of processes
  - Contracting, Development, T&E, Deploy
- Commercial capabilities & technologies
- Modeling & Simulation usage
- Virtual platform (Lab) usage --
  - Development, T&E, Demos/Exercises

4.5

Challenges for C4ISR&T

Avionics

- Vertical & Horizontal Connectivity
- Bandwidth, Robustness, Timeliness, Interoperability
- Network Centric -- Sensor, Control and Engagement Grids
- Targeting Information -- Expedited, Seamless, BDA Feedback
- Blue (as well as Red) Situational Awareness

4.5 Avionics

NAST C4ISR&T Working Group

- Coordination --
  - "East and West"
- Operational and Systems Architecture
  - Define for naval aviation
- Participation in Doctrine and Architecture defining events --
  - Demos, Exercises, Battle Experiments

C4ISR&T Coordination

- Systems Engineering approach --
  - Cross-Competency coordination
  - Cross-Systems Command and Programs
  - Teaming with Industry

Participation

- Labs -- Use as Virtual Platforms for:
  - Demonstrations --
    - Brassboard Capabilities
    - Insertion of new Technology
  - Nodes in Exercises / Battle Experiments
    - Doctrine and Architecture-defining events
  - Development of systems
  - Test & Evaluation -- own and cross-platform

Capabilities to Address

- Mission Planning & Rehearsal
- Command & Control of Air Assets --
  - Current Status,
  - Mission changes and results
- Sensor-to-Shooter capabilities --
  - Threat, Targeting, and BDA info

Technical Compliance

Avionics

- Interoperability-driven requirements --
  - Navy air, surface and sub-surface connectivity
  - Joint, Allied, and Coalition connectivity
- Joint Technical Architecture (JTA)
- Defense Information Infrastructre (DII) Common Operating Environment (COE)
- Global Command & Control System (GCCS) -- special connectivity requirements

4.5

Overall Objectives

Avionics

- Naval Aviation as full partner --
    - C4ISR&T Doctrine and Architecture
- Network Centric connectivity
    - Response to varied / changing battle situations
- Streamlined Acquisition capability
- Infrastructure that is interoperable for:
    - Development, T&E, Participation as Nodes in Demos and Exercises

Questions???

The Application of Statistical Methods to Software Test

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Why do we test software?

Example objectives:

- Demonstrate that, at this point in the life cycle, the process is in control.
- Demonstrate that the software is ready for fielding.

How do we measure the success or failure of the software test?

We apply scientific investigation methods:

- Formulate hypotheses based on objectives
- Design experiments to test the hypotheses
- Perform experiments
- Evaluate results
- Develop conclusions based on results

Formulate hypotheses

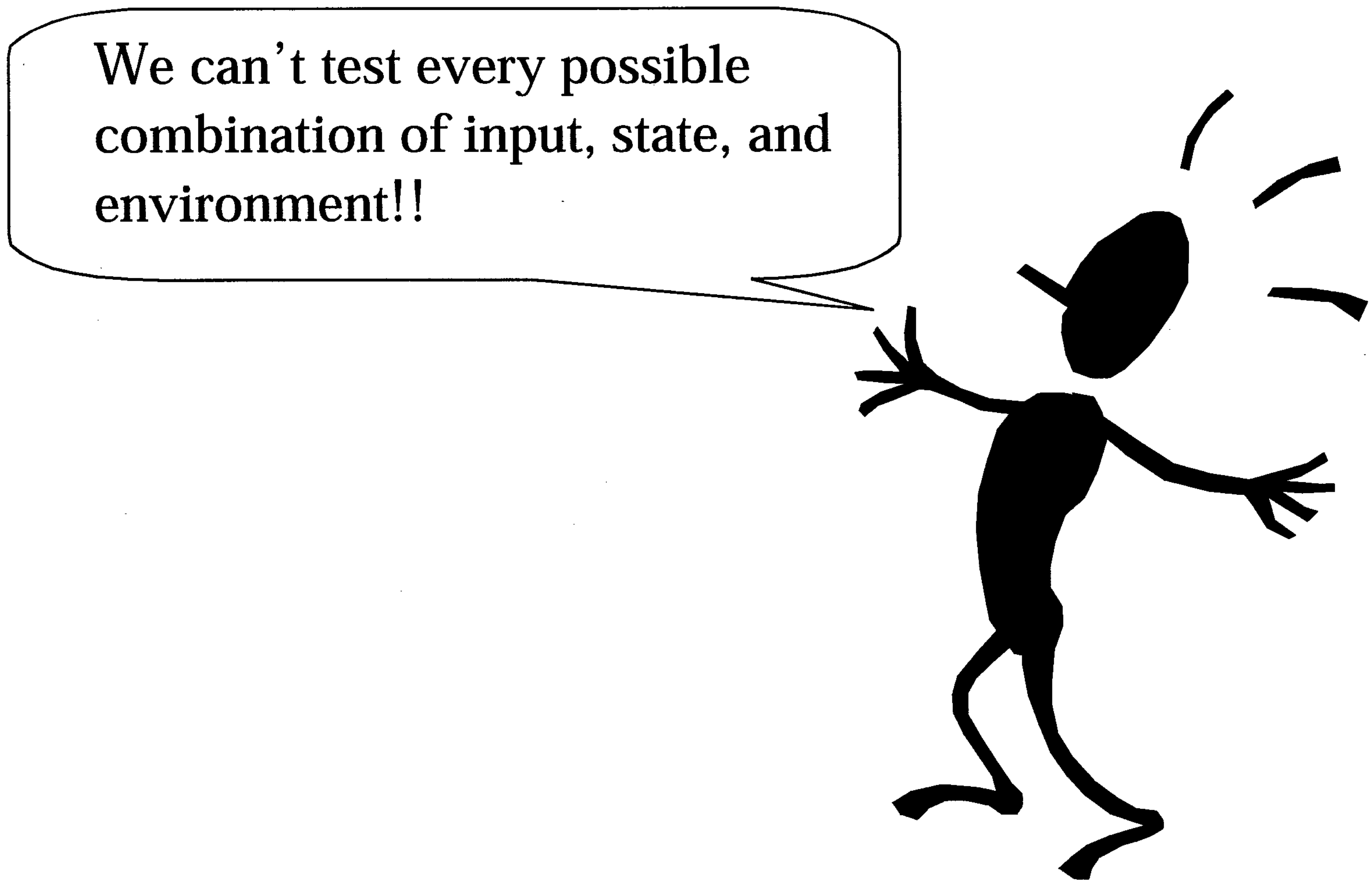
Example objective:

"Demonstrate that the process is in control"

Example hypothesis:

"The software will experience no more than ___ failures of type ___ when tested under ___ conditions."

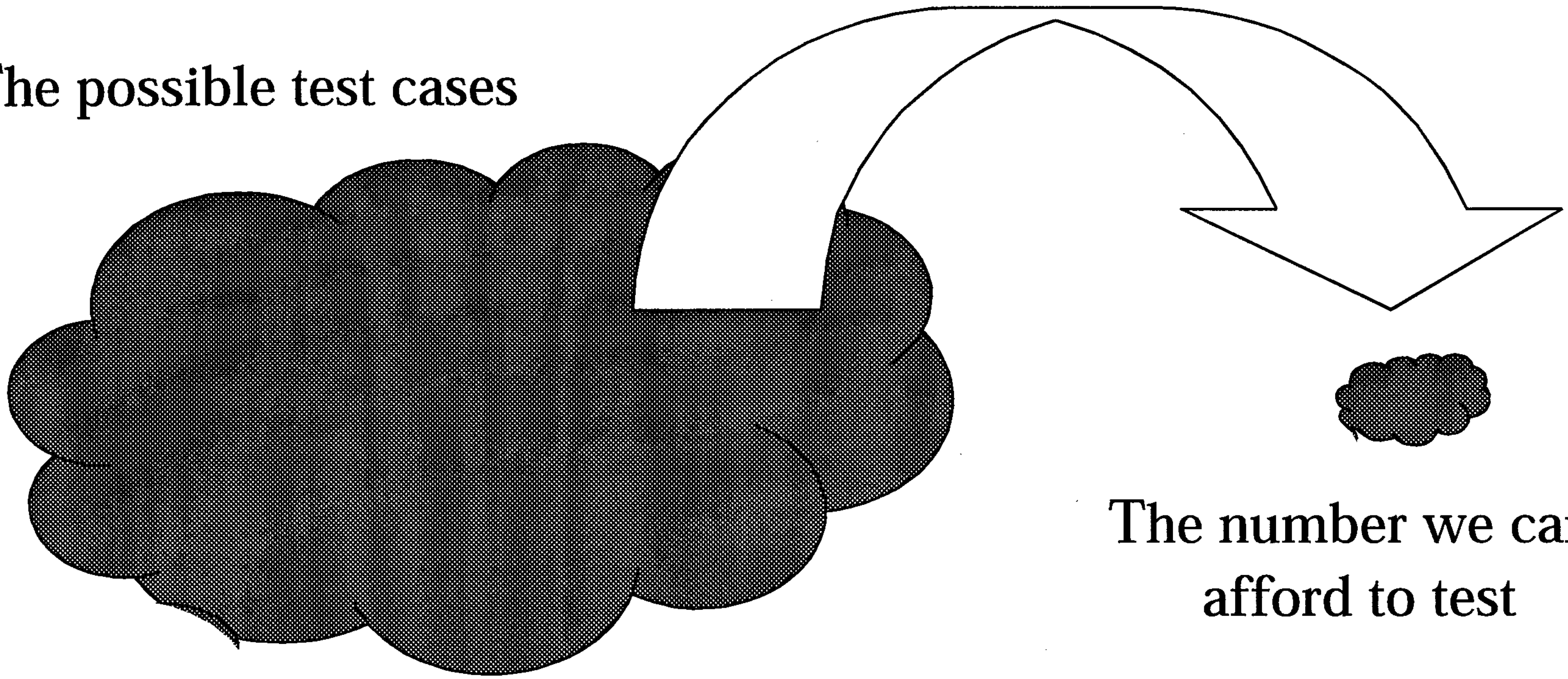
Design an experiment: How???



Software Testing is Sampling

(How do we select the sample?)

The possible test cases



The number we can
afford to test

(What is the risk of not testing all?)

There are many test case selection techniques

ï Political considerations

ï Existing regression test suites

ï Boundary value analysis

ï Code coverage

ï Functional coverage

ï Use case analysis

ï . . .

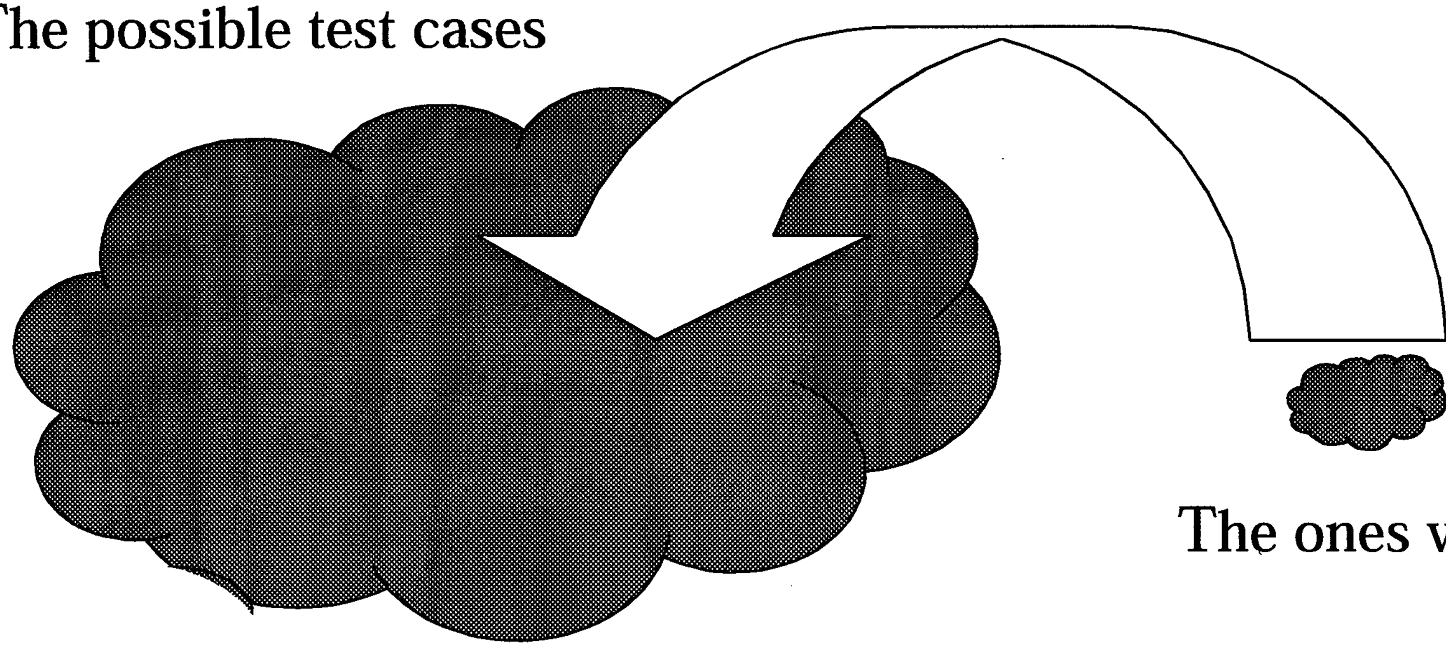
The Hard Fact

After we finish testing, there are two distinct sets:

ï Our sample: the test cases we executed and evaluated -- we know something about these.

ï The rest of the population: the test cases we didnít execute -- the user will be the first to execute these.

Conclusions based on test results



Statistical methods for test and evaluation of software

ï Scientific investigation methods to guide the test activities.

ï Experimental design methods to characterize and represent the population of possible software use.

ï Mathematical modeling, simulation, and analysis to support test planning, execution, and evaluation.

Statistical methods (cont.)

- Operations research techniques for specifying objectives and constraints, performing analyses, and making optimal choices.
- Statistical methods for partitioning the population of possible software use, selecting statistically valid samples, and making inferences to the entire population based on results from testing the sample.

Benefits of statistical methods

ï Quantitative analysis of software specifications before code is completed.

ï Quantitative test planning and evaluation support.

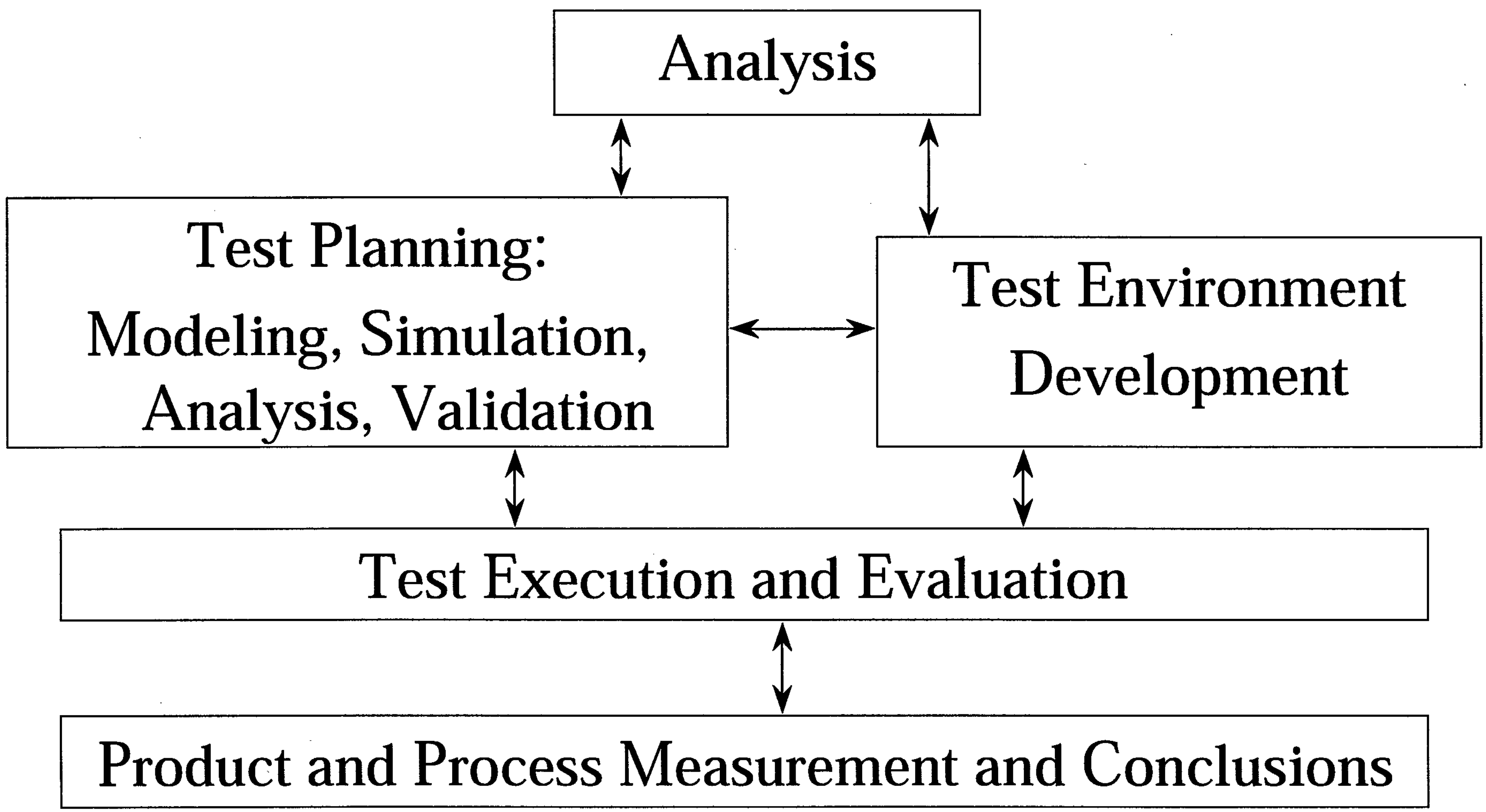
ï Automatic generation of statistically correct sample of test cases.

ï Test and evaluation simulation.

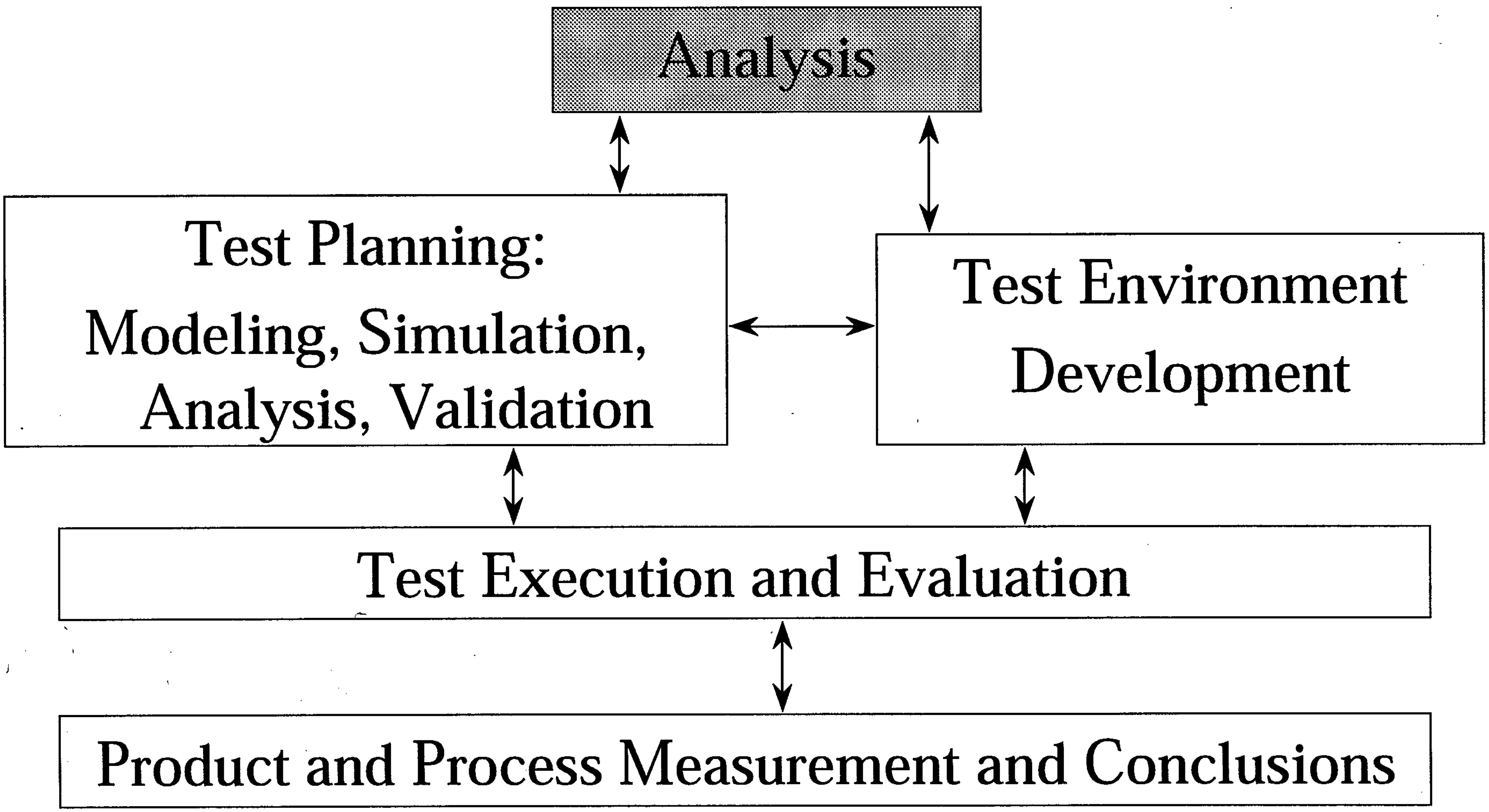
ï Support for automated test execution and evaluation.

ï Quantitative analysis of test results.

The Statistical Testing Process



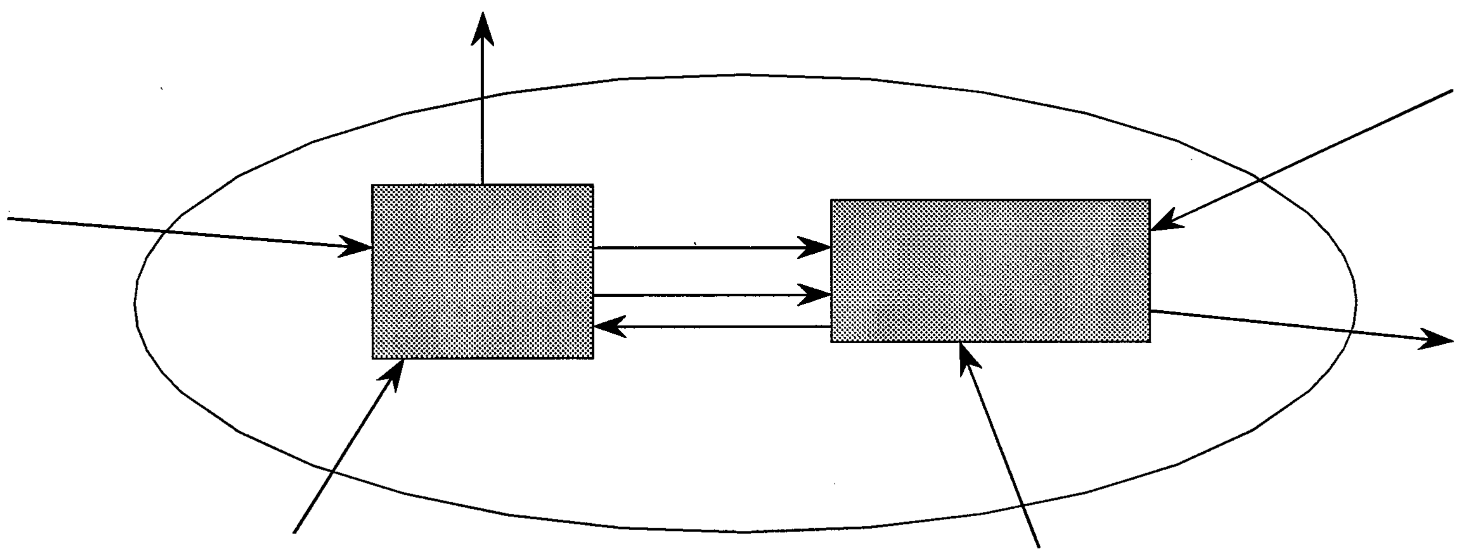
The Statistical Testing Process



Determine test boundary

ï What part(s) of the software do we test?

ï In what environment?



Determine specific test objectives and constraints

Sources of objectives and constraints:

ï Expected or hypothesized usage

ï Management issues (cost, schedule, priorities, Ö)

ï Technical issues (features, requirements traceability, test environment, dependencies with other test and development schedules, Ö)

Consider life cycle phases

At different points in the life cycle, the test objectives will differ. For example:

ï ìCover all usage states as quickly as possible to get an early indication of quality.î

ï ìMimic as closely as possible a particular category of expected usage. Test enough to give a statistically valid estimate of reliability for this usage category.î

Evaluate test strategies

ï Simulation or operational test

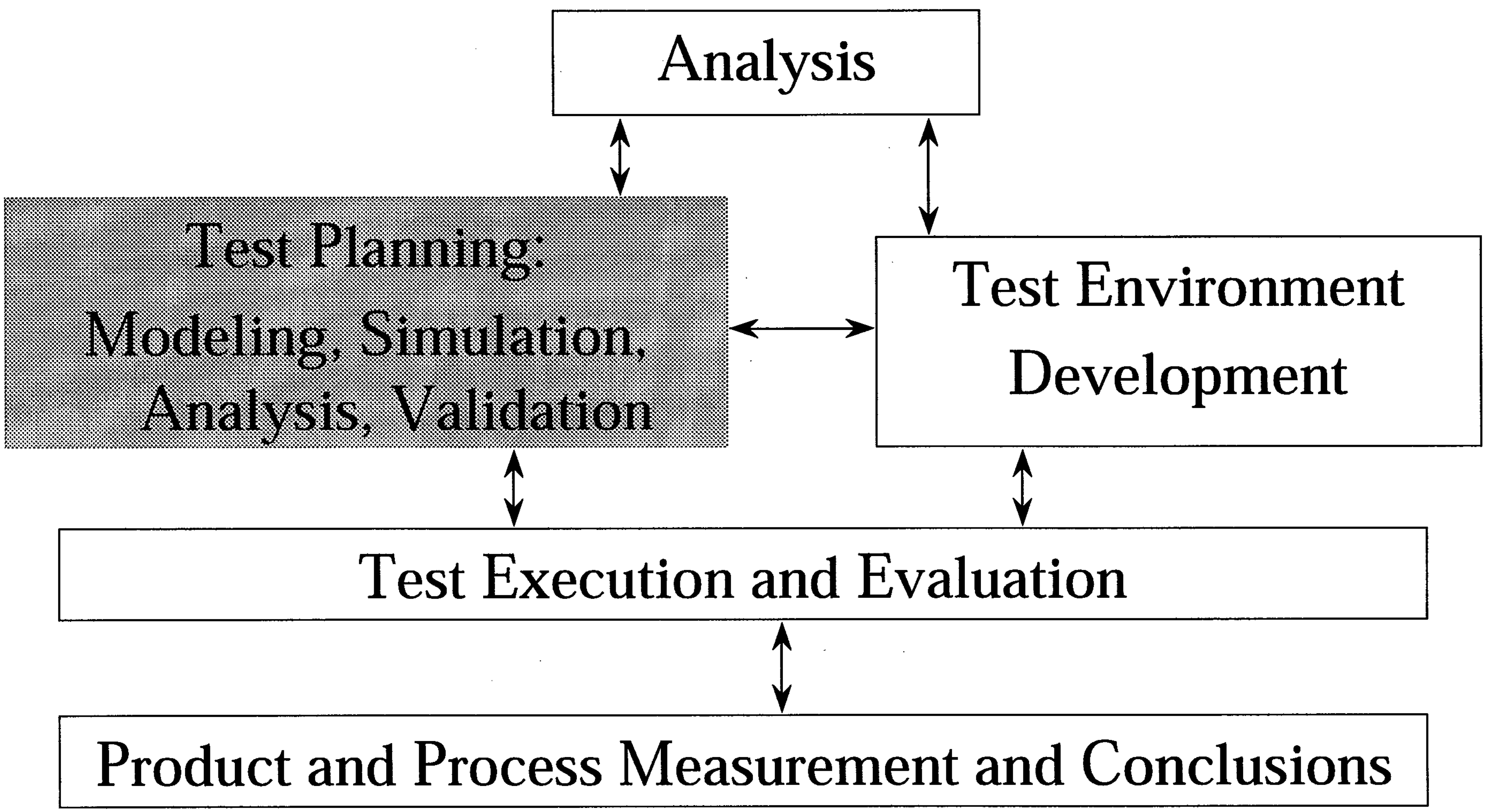
ï Degree of automation

ï Oracle

ï Stopping criteria

ï Ö

The Statistical Testing Process



Usage modeling: characterize the population of possible use

ï Precisely define high level usage stratification

  ñ users

  ñ uses

ï Determine how many models to develop

Usage modeling: represent the population of possible use

ï Build a formal representation of all possible uses of the system for each user/use.

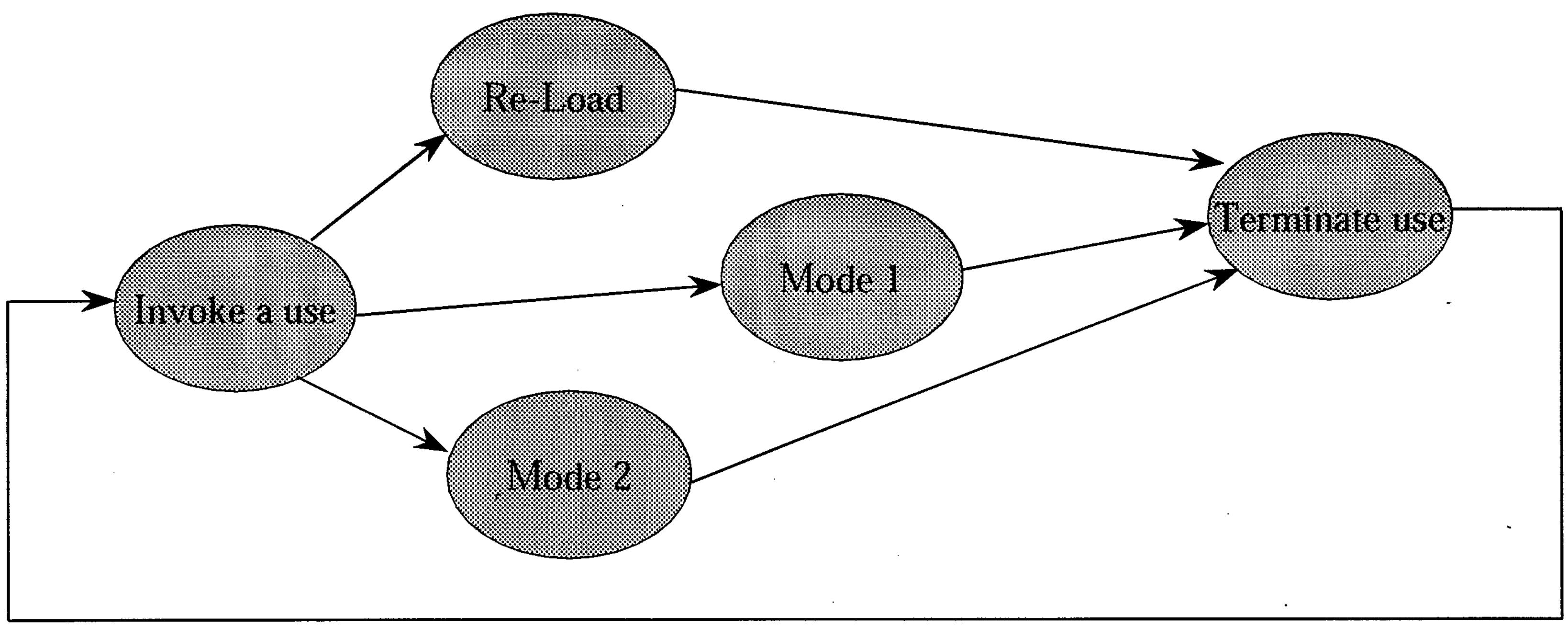
ï Select a modeling strategy that will support statistical analyses for model validation, test planning, and test evaluation.

Markov chain usage models

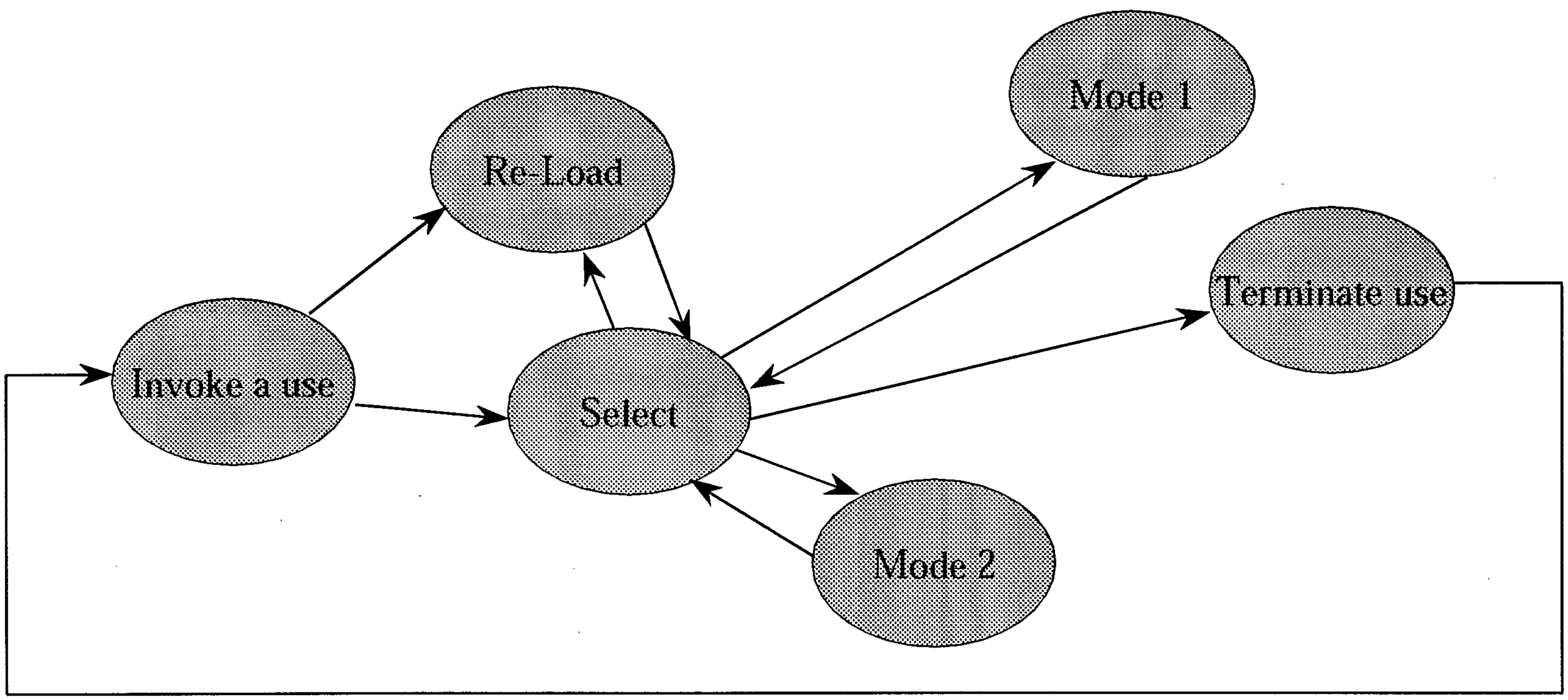
ï The structure of a usage model for a system is a hierarchy of component usage models.

ï Each component modelís structure can be represented by a state transition graph: nodes represent states of use and arcs represent possible transitions between states.

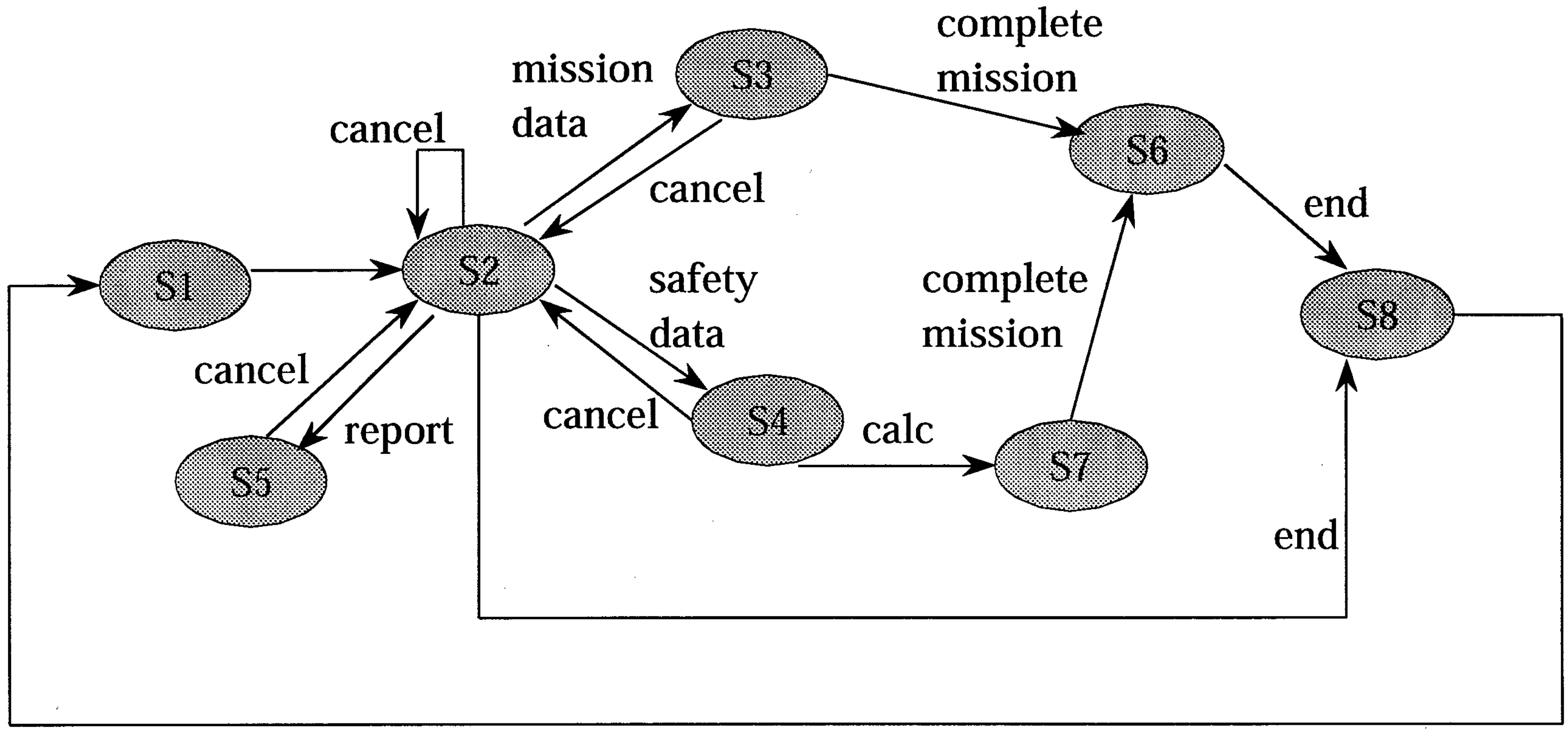
High-level usage model structure: use stratified by mode of operation



High-level usage model structure: based on functional specification



Second-level usage model structure: Mode 1



Usage model structure validation

ï Does the model represent all possible uses?

ï How do the paths, test evaluation criteria, and test environment map to software requirements?

ï Do we need multiple arcs between two particular states to represent selection of different data or performing different procedures?

ï What determines successful execution at each state?

UM structure validation (cont.)

- What data are required at each arc?
- What procedures are required to set up the data, execute the test, and capture and evaluate the results?
- Can we execute and evaluate each path?
- Can we automate test execution and evaluation?
- ...

State transition probabilities

- We model software use as a stochastic process with decisions to be made at each state.
- Each arc is assigned a transition probability.
- The model yields a transition probability matrix. (finite state, discrete parameter, time homogeneous, recurrent Markov chain)
- We can draw on the rich body of Markov chain mathematics to analyze the model.

Specify probabilities as mathematical functions: use constraints and objectives

ï ìat state 2 a user enters mission data 30% of the timeî would be represented as: $p_{s2,s3} = 0.3$

ï Typically there is insufficient information to specify a value. ìIt is at least 3 time more important that we test the transition from s2 to s4 than the transition from s2 to s5î would be represented as: $p_{s2,s5} < 3^{*}p_{s2,s4}$

UM maintenance and reuse

ï Update the functions as new information is available about expected use, test constraints, test objectives.

ï Use standard mathematical programming techniques to determine an optimal set of transition probabilities to use for testing.

ï Reuse a usage model structure with different transition probabilities at different points in the life cycle.

Usage model analysis

From the model, calculate statistics such as

ï length of average test sequence

ï estimated proportion of test budget that will be spent testing a particular part of the model

ï amount of testing required before reaching a particular state or arc

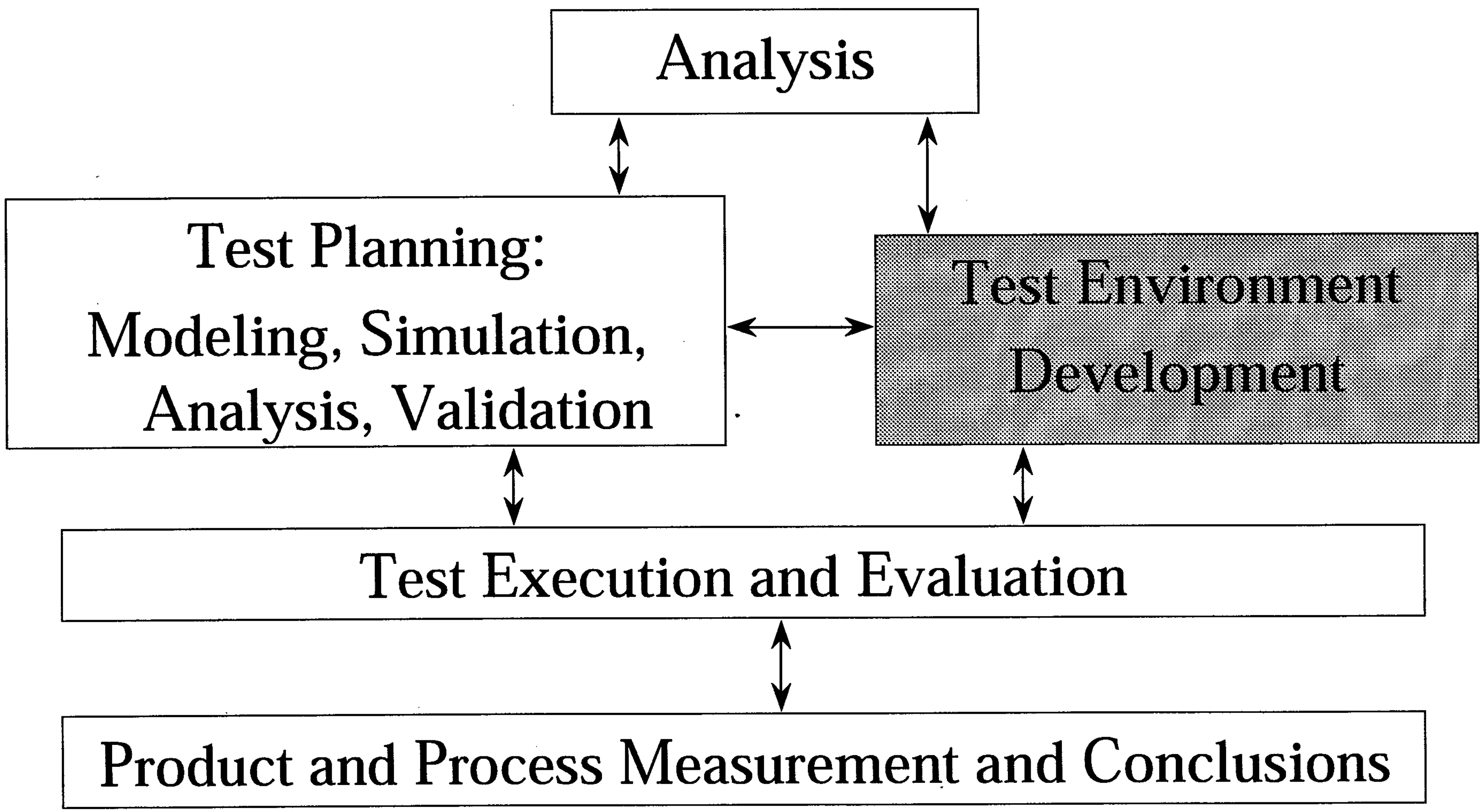
ï probability of a particular state occurring in a test sequence

ï number of statistically typical paths in the model

Test simulation

- Automatically generate test sequences from the model.
- Make hypotheses about test results.
- Generate a Markov chain to represent the test experience.
- Analyze the simulated testing chain.
  - model validation
  - test planning support

The Statistical Testing Process

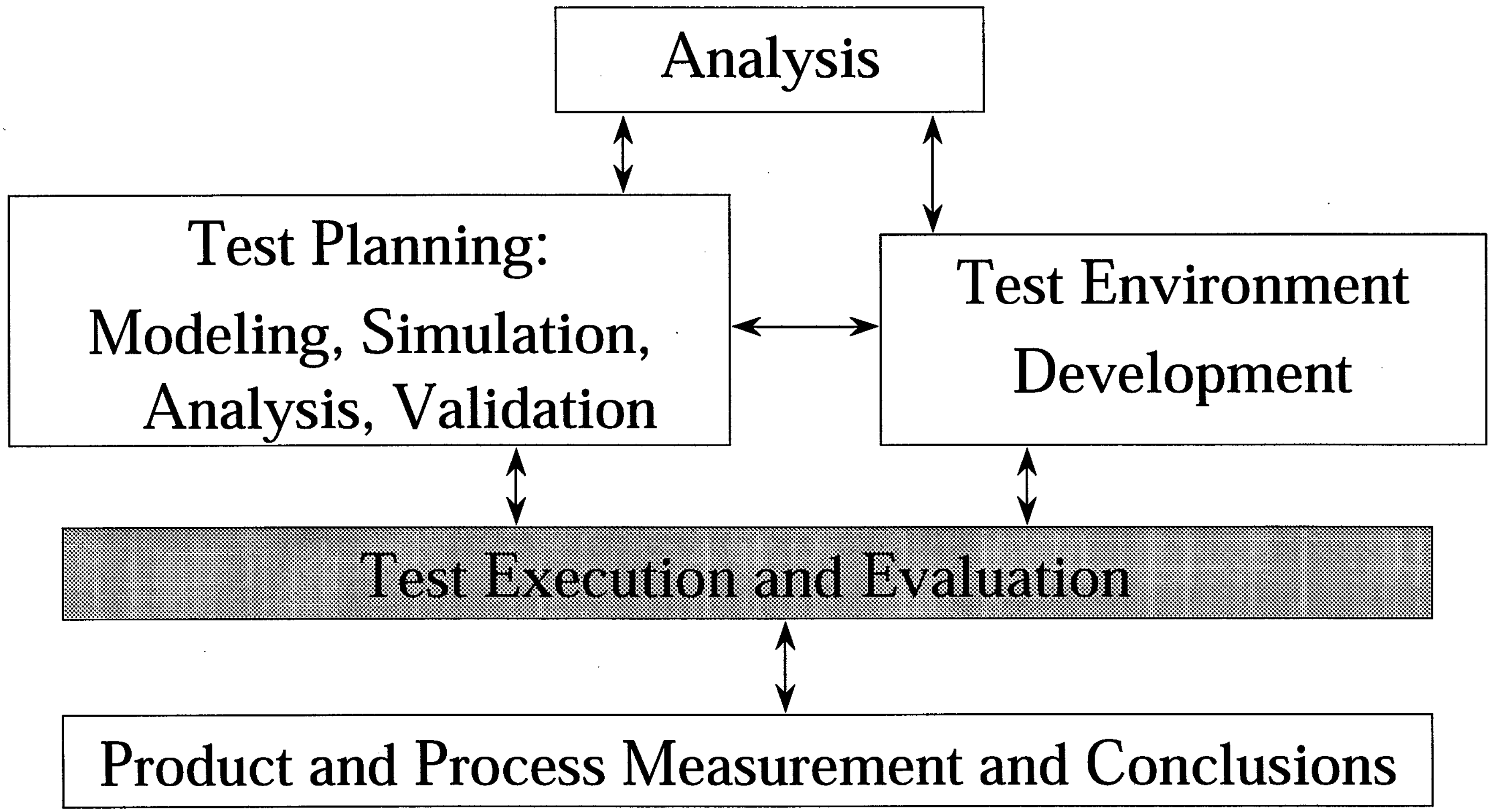


Test environment development

ï Parallel effort to application development

ï Often is a significant effort

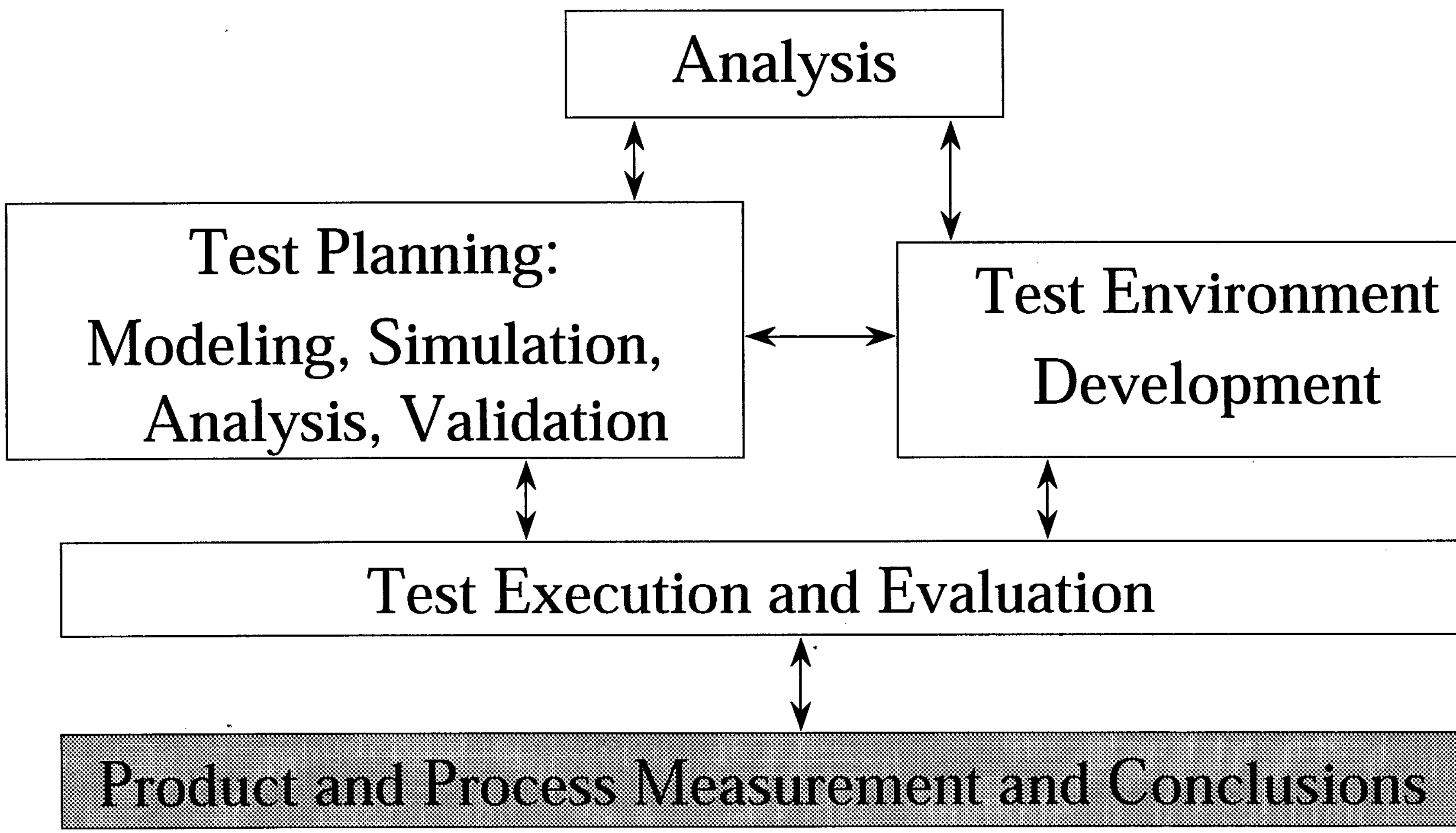
The Statistical Testing Process



Sequence of events

- ï Develop usage model and oracle.
- ï Automatically generate test sequences.
- ï Transform sequences as required to support automation.
- ï Execute scripts on the system under test (use an automated test runner if available).
- ï Evaluate test results using the oracle.

The Statistical Testing Process



Measurement

ï Build a Markov chain from test results.

ï Compare testing chain to usage model and calculate measures of

  ñ reliability

  ñ test sufficiency.

ï Recognize that these are calculated statistics based on the testing. (And that is all that they are!)

Determine conclusions

- ï Evaluate the entire testing process
  - ñ How well did we characterize and represent the population of use?
  - ñ How many test sequences did we execute and evaluate?
  - ñ What types of usage do these sequences represent?
  - ñ What data, procedures, and environment did we use?
  - ñ What possible paths through the model did we NOT execute and/or evaluate?
  - ñ What possible data (input, state, and environment) combinations did we NOT use?
- ï What conclusions can we make?

ITCN
SOLUTIONS FOR EMBEDDED SYSTEMS INTEGRATION

C-TAC COMPUTER TESTER ANALYZER CONTROLLER

JAWS Symposium & Exhibition
June 18, 1998

SOLUTIONS FOR EMBEDDED SYSTEM DEVELOPMENT

C-TAC

EMBEDDED SYSTEM ANALYZER

APPLICATION SUMMARY

PLATFORMS

- AV-8B
- A-10
- B-2
- C-17
- C-130
- AC-130U
- EA-6B
- F-14
- F-15
- F-15I
- F-18
- CF-18
- RAAF-18
- F-111
- GR-7
- P-3
- A-4

PROGRAMS

- ACM
- ALQ-135
- AN/ALQ-172
- ATARS
- AYK-14
- CASSINI
- CDNU
- IDAL
- SCNS
- SOF-EISE
- ALQ-155

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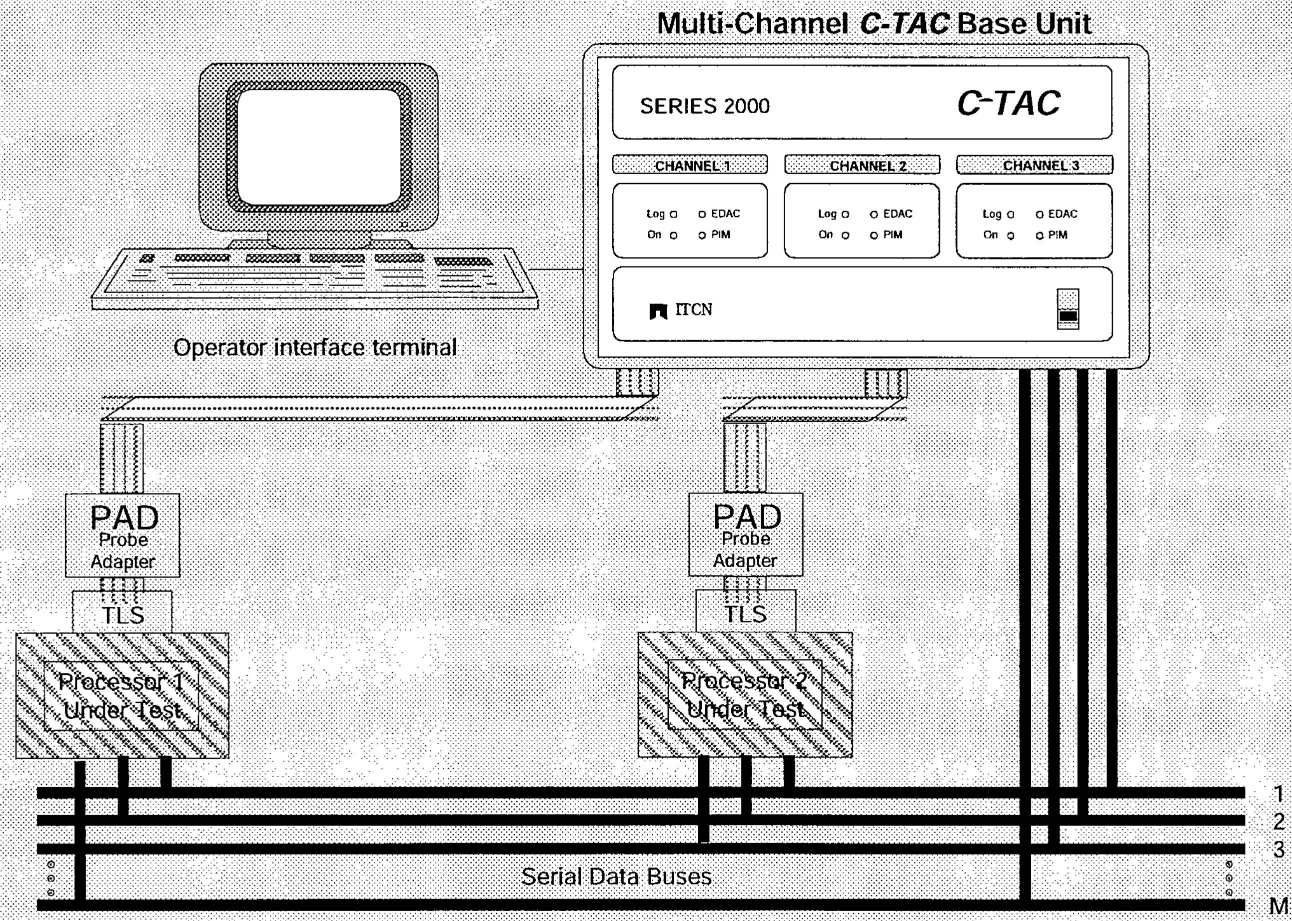
SOLUTIONS FOR EMBEDDED SYSTEMS INTEGRATION

C-TAC COMPUTER TESTER ANALYZER CONTROLLER



Typical multiple target application of *C-TAC* with N processors and M data buses

C-TAC EMBEDDED SYSTEM ANALYZER

What is C-TAC?

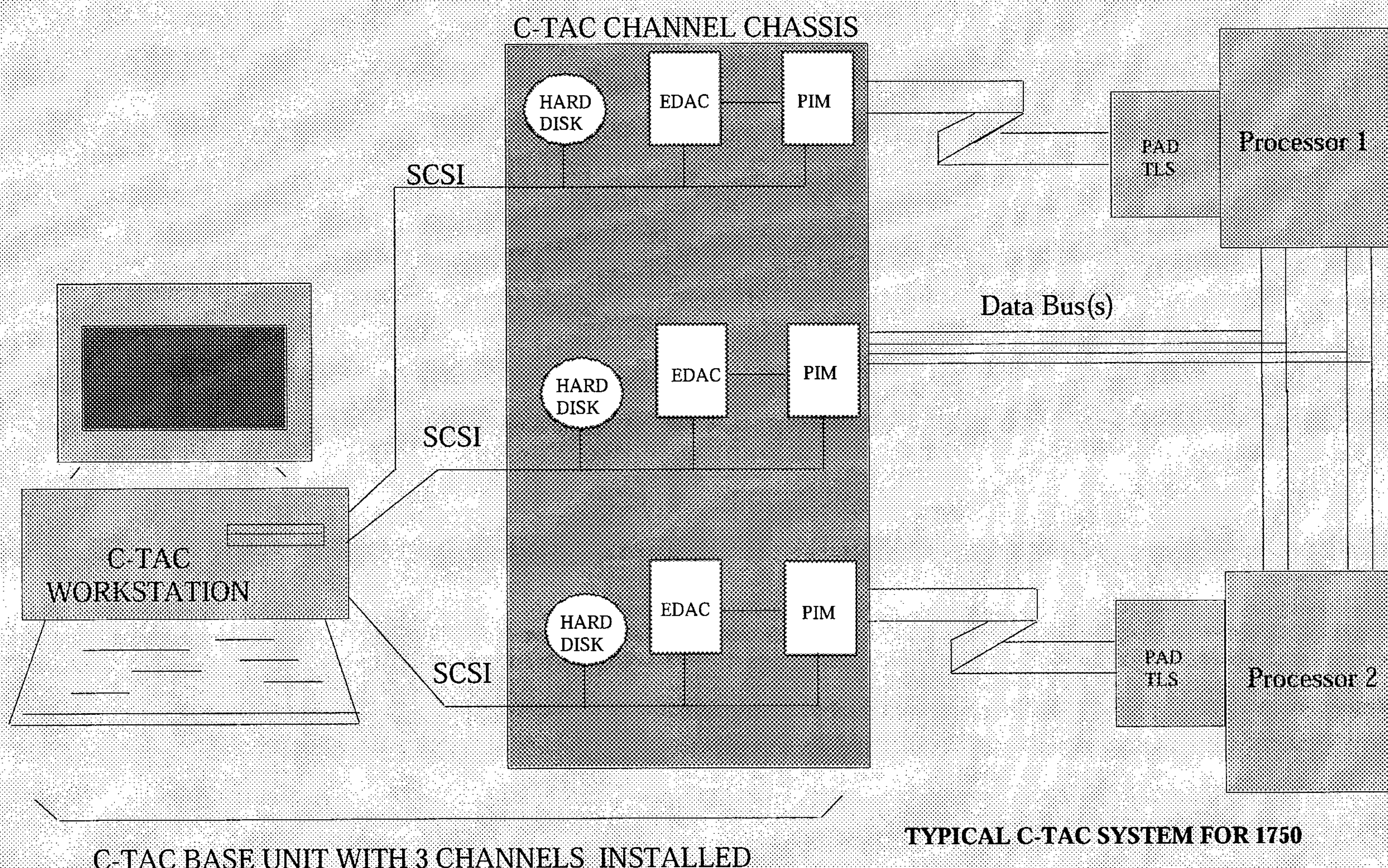
6 Embedded Computer System Development Tool

6 Combination of Data Acquisition, Logic Analyzer, Bus Analyzer, and In-Circuit Emulator in a User Friendly, Integrated Package

6 Stand-Alone Instrument Controlled by a Personal Computer (Included)

6 Tailored to Users Processor/Bus Application

C-TAC Components



TYPICAL C-TAC SYSTEM FOR 1750

1173

What Does C-TAC Do?

6 Traces Data Flow Throughout the System

6 Monitors Multiple Targets in Real-Time without Impacting System Timing or Event Sequencing

6 Collects Data “Smartly” based on Hardware Filtering

6 Interfaces to Compiler Tools for “Point and Click” Symbolic Specification of Data to be Monitored

6 Displays Engineering Units in addition to Raw Data (Binary, Octal, Hex)

6 Includes Classical Debugger Features for Processor Channels

6 Supports Ada Level Software Debuggers

How is C-TAC Used?

- 6 Processors
  - Data Tracing
    - » Monitor Variables for Anomalies and Determine Instruction/Routine Causing Anomalous Behavior
    - » Monitor for Critical Combinations of Events or Data Values
  - Timing
    - » Transport Delays within Processor Software
    - » Execution Time Profiles of Software
    - » "Spare" Execution Time Available
  - Instruction Tracing
    - » Full Trace Capability by Routine
    - » Jump Traces
    - » Calling Tree Determination
    - » Program Flow

How is C-TAC Used (Continued)?

- Buses
  - Data Tracing
    - » Monitor Variables for Anomalies and Determine which Terminal Generated Anomalous Data
    - » Monitor for Critical Combinations of Events or Data Values
- Timing
  - Data Bus Transport Delays
  - Bus Message Sequence Verification
  - Bus Timing Profiles
- Statistics
  - Bus Loading
  - Message Errors
  - Bit Errors

How is C-TAC Used (Continued)?

6 System
- Data Tracing
  - » System-Wide Capability through cross-channel triggers
  - » Cross-Channel Event Combinations used to Qualify Data Collection
  - » System Data Flow Tracing
- Timing
  - » System Transport Delays
  - » System Loading
  - » Critical Timing/Loading Determination
  - » Critical Process Sequencing across Subsystem Boundaries

What are the Benefits?

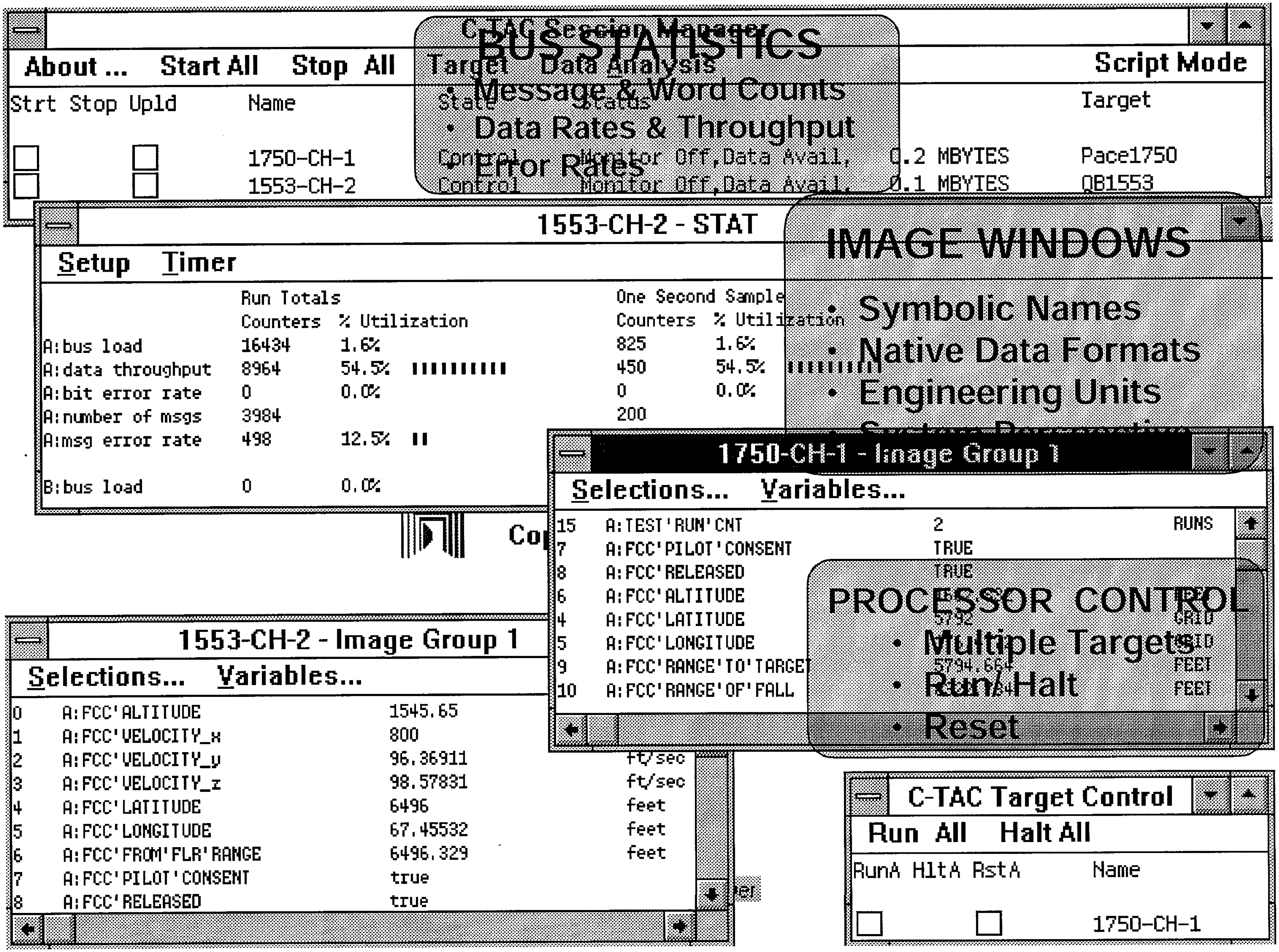
6 Enhanced Productivity
- Symbolic Test Specification and Data Display
- Sophisticated Filtering Collects only Data of Interest under Conditions of Interest
- Linked Analysis Tools Support Instant Location of Anomalous Raw Data
- Graphical Presentation of Procedure/Bus Message Timing
- On-Line Statistics for 1553 Buses

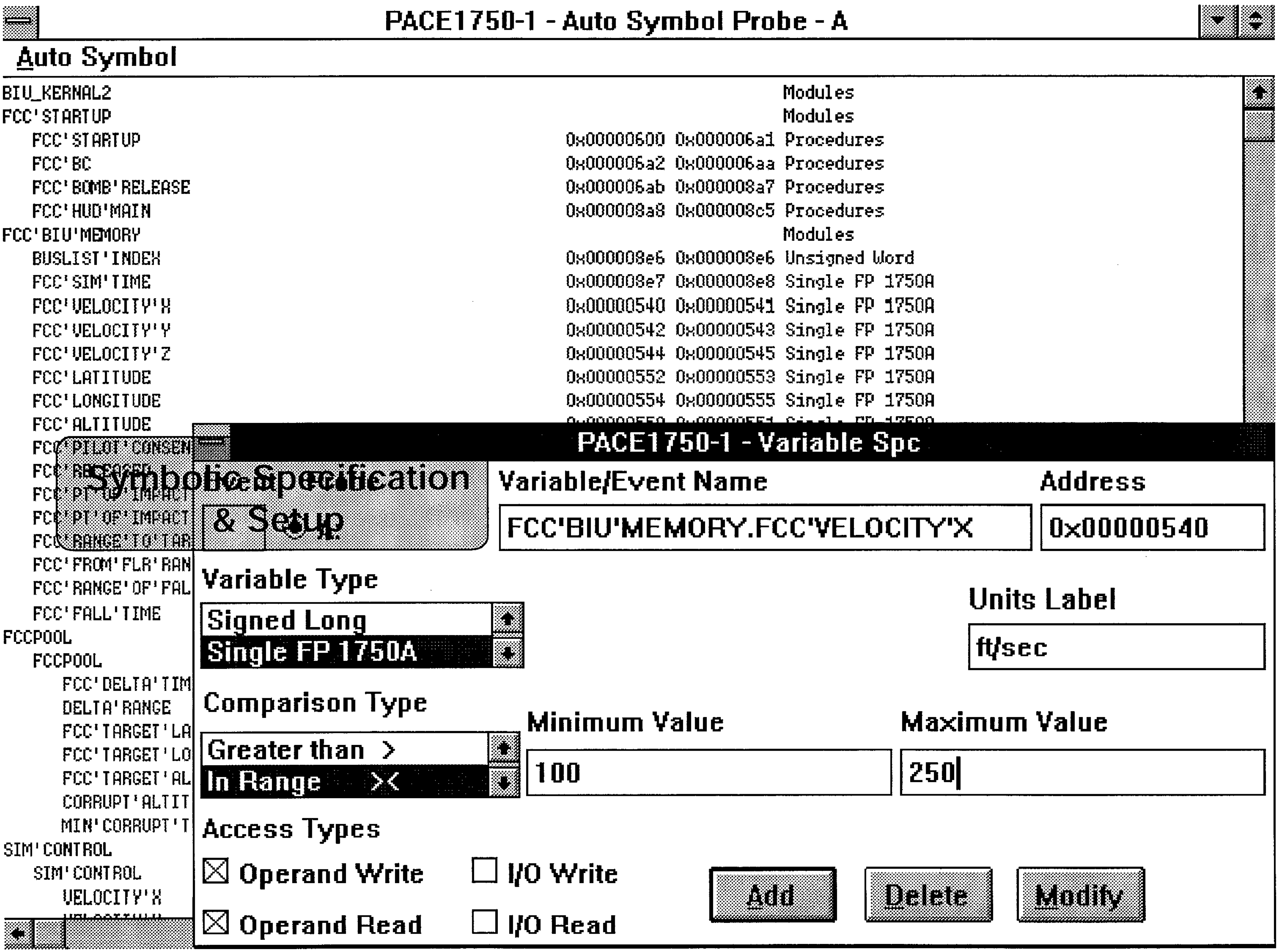
6 Reduced System Integration Time
- Multi-Channel C-TAC Monitors Multiple Points in System
- Critical System Timing Easily determined
- End-to-End Verification of Data Flow and Timing
- Critical System Procedure Flow Verification

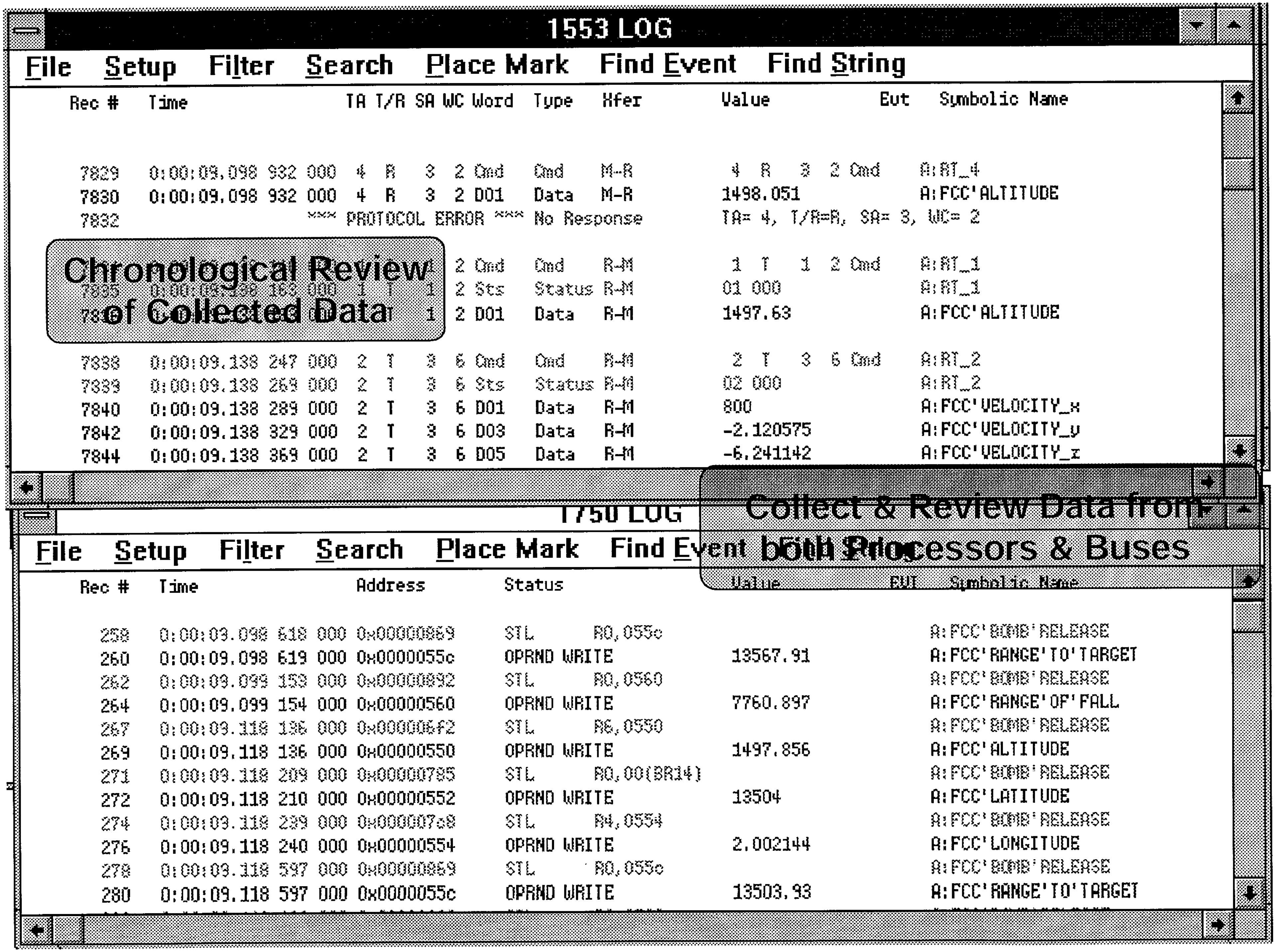
What are the Benefits (Continued)?

6 Improved System Quality
  - More Thorough Evaluation
  - Improved Understanding of Intra-System Relationships
  - Improved Ability to Verify Data and Processes

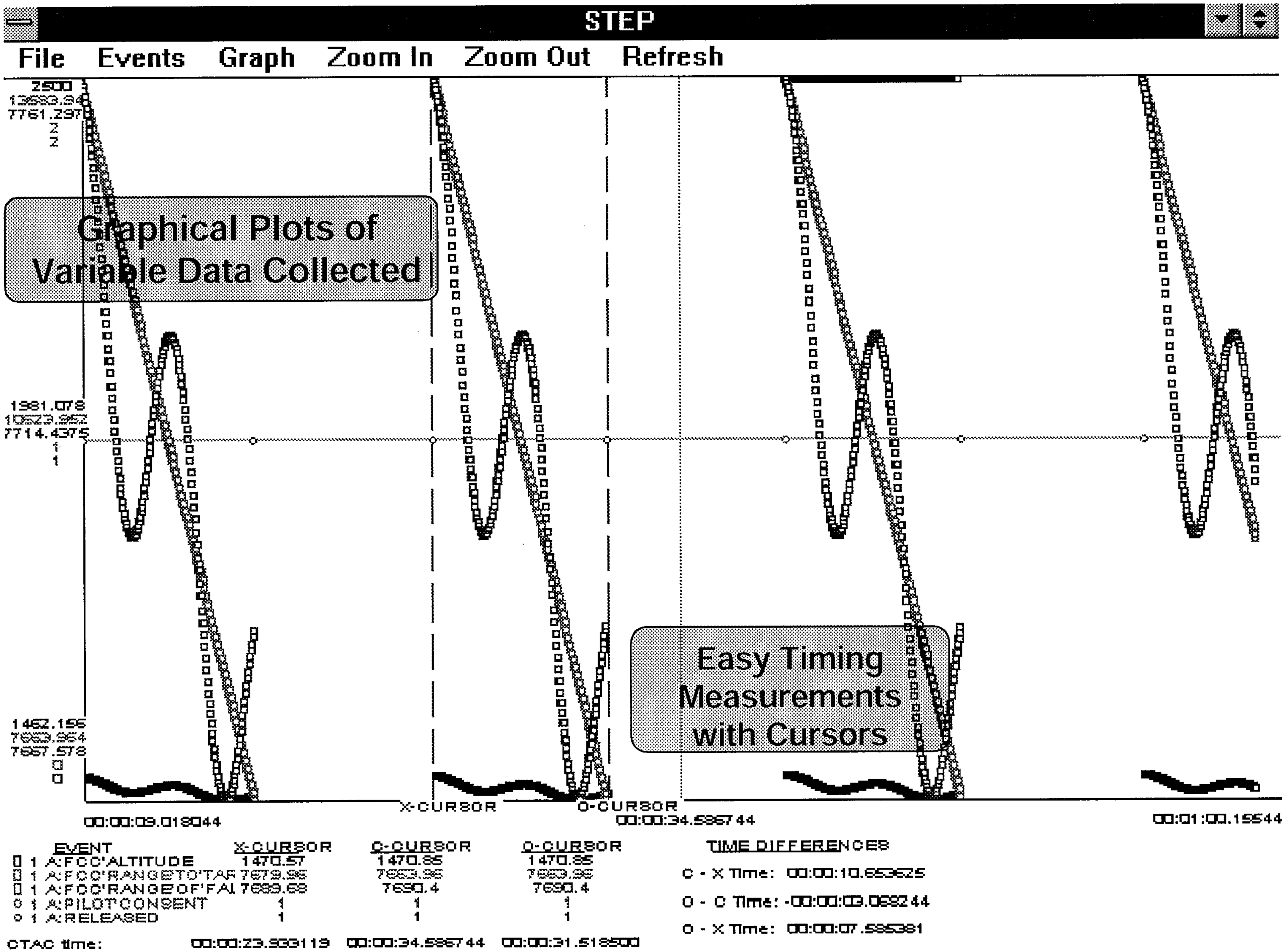
6 Reduced Costs
  - Fewer Personnel due to Enhanced Productivity
  - Reduced Time to Develop and Integrate
  - Fewer Latent Problems


BUS STATISTICS
• Message & Word Counts
• Data Rates & Throughput
• Error Rates
IMAGE WINDOWS
• Symbolic Names
• Native Data Formats
• Engineering Units
PROCESSOR CONTROL
• Multiple Targets
• Run/Halt
• Reset
About ... Start All Stop All Target Data Analysis Script Mode
Strt Stop Upld Name Target
1750-CH-1 0.2 MBYTES Pace1750
1553-CH-2 0.1 MBYTES QB1553
1553-CH-2 - STAT
Setup Timer
Run Totals
Counters % Utilization
One Second Sample
A:bus load 16434 1.6% 825 1.6%
A:data throughput 8964 54.5% 450 54.5%
A:bit error rate 0 0.0% 0 0.0%
A:number of msgs 3984 200
A:msg error rate 498 12.5%
B:bus load 0 0.0%
1750-CH-1 - Image Group 1
Selections... Variables...
15 A:TEST'RUN'CNT 2 RUNS
7 A:FCC'PILOT'CONSENT TRUE
8 A:FCC'RELEASED TRUE
6 A:FCC'ALTITUDE
4 A:FCC'LATITUDE
5 A:FCC'LONGITUDE
9 A:FCC'RANGE'TO'TARGET
10 A:FCC'RANGE'OF'FALL
1553-CH-2 - Image Group 1
Selections... Variables...
0 A:FCC'ALTITUDE 1545.65
1 A:FCC'VELOCITY_x 800
2 A:FCC'VELOCITY_y 96.36911 ft/sec
3 A:FCC'VELOCITY_z 98.57831 ft/sec
4 A:FCC'LATITUDE 6496 feet
5 A:FCC'LONGITUDE 67.45532 feet
6 A:FCC'FROM'FLR'RANGE 6496.329 feet
7 A:FCC'PILOT'CONSENT true
8 A:FCC'RELEASED true
C-TAC Target Control
Run All Halt All
RunA HltA RstA Name
1750-CH-1

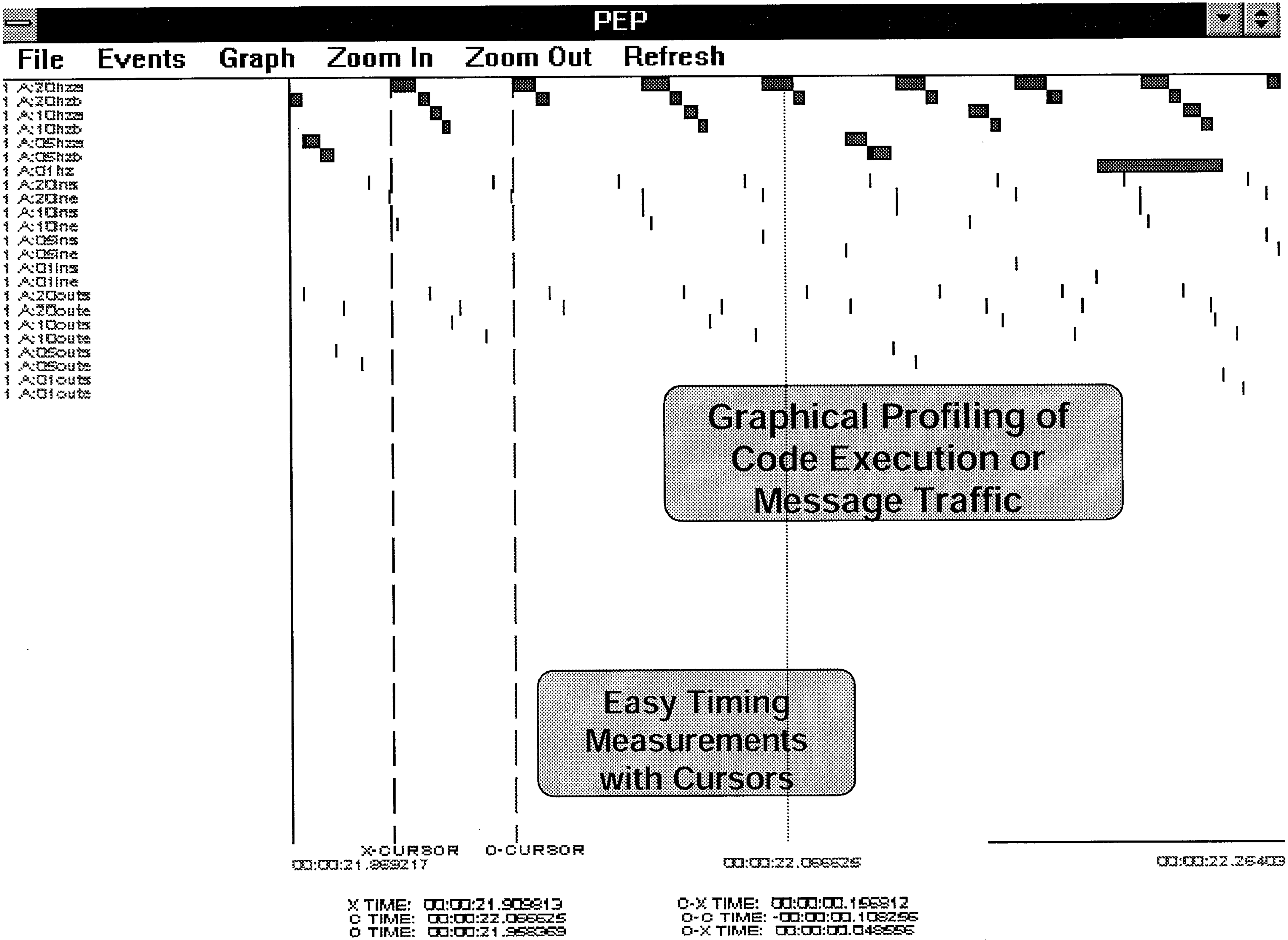

PACE1750-1 - Auto Symbol Probe - A
Auto Symbol
BIU_KERNAL2 Modules
FCC'STARTUP Modules
FCC'STARTUP 0x00000600 0x000006a1 Procedures
FCC'BC 0x000006a2 0x000006aa Procedures
FCC'BOMB'RELEASE 0x000006ab 0x000008a7 Procedures
FCC'HUD'MAIN 0x000008a8 0x000008c5 Procedures
FCC'BIU'MEMORY Modules
BUSLIST'INDEX 0x000008e6 0x000008e6 Unsigned Word
FCC'SIM'TIME 0x000008e7 0x000008e8 Single FP 1750A
FCC'VELOCITY'X 0x00000540 0x00000541 Single FP 1750A
FCC'VELOCITY'Y 0x00000542 0x00000543 Single FP 1750A
FCC'VELOCITY'Z 0x00000544 0x00000545 Single FP 1750A
FCC'LATITUDE 0x00000552 0x00000553 Single FP 1750A
FCC'LONGITUDE 0x00000554 0x00000555 Single FP 1750A
FCC'ALTITUDE
FCC'FROM'FLR'RAN
FCC'RANGE'OF'FAL
FCC'FALL'TIME
FCCPOOL
FCCPOOL
FCC'DELTA'TIM
DELTA'RANGE
FCC'TARGET'LA
FCC'TARGET'LO
FCC'TARGET'AL
CORRUPT'ALTIT
MIN'CORRUPT'T
SIM'CONTROL
SIM'CONTROL
VELOCITY'X
Symbolic Specification & Setup
PACE1750-1 - Variable Spc
Variable/Event Name
FCC'BIU'MEMORY.FCC'VELOCITY'X
Address
0x00000540
Variable Type
Signed Long
Single FP 1750A
Units Label
ft/sec
Comparison Type
Greater than >
In Range ><
Minimum Value
100
Maximum Value
250
Access Types
Operand Write
I/O Write
Operand Read
I/O Read
Add
Delete
Modify


1553 LOG
File Setup Filter Search Place Mark Find Event Find String
Rec # Time TA T/R SA WC Word Type Xfer Value Evt Symbolic Name
7829 0:00:09.098 932 000 4 R 3 2 Cmd Cmd M-R 4 R 3 2 Cmd A:RT_4
7830 0:00:09.098 932 000 4 R 3 2 D01 Data M-R 1498.051 A:FCC'ALTITUDE
7832 *** PROTOCOL ERROR *** No Response TA= 4, T/R=R, SA= 3, WC= 2
2 Cmd Cmd R-M 1 T 1 2 Cmd A:RT_1
2 Sts Status R-M 01 000 A:RT_1
2 D01 Data R-M 1497.63 A:FCC'ALTITUDE
Chronological Review of Collected Data
7838 0:00:09.138 247 000 2 T 3 6 Cmd Cmd R-M 2 T 3 6 Cmd A:RT_2
7839 0:00:09.138 269 000 2 T 3 6 Sts Status R-M 02 000 A:RT_2
7840 0:00:09.138 289 000 2 T 3 6 D01 Data R-M 800 A:FCC'VELOCITY_x
7842 0:00:09.138 329 000 2 T 3 6 D03 Data R-M -2.120575 A:FCC'VELOCITY_y
7844 0:00:09.138 369 000 2 T 3 6 D05 Data R-M -6.241142 A:FCC'VELOCITY_z
1750 LOG
File Setup Filter Search Place Mark Find Event
Collect & Review Data from both Processors & Buses
Rec # Time Address Status Value EVT Symbolic Name
259 0:00:09.098 618 000 0x00000869 STL R0,055c A:FCC'BOMB'RELEASE
260 0:00:09.098 619 000 0x0000055c OPRND WRITE 13567.91 A:FCC'RANGE'TO'TARGET
262 0:00:09.099 153 000 0x00000892 STL R0,0560 A:FCC'BOMB'RELEASE
264 0:00:09.099 154 000 0x00000560 OPRND WRITE 7760.897 A:FCC'RANGE'OF'FALL
267 0:00:09.118 136 000 0x000006f2 STL R6,0550 A:FCC'BOMB'RELEASE
269 0:00:09.118 136 000 0x00000550 OPRND WRITE 1497.856 A:FCC'ALTITUDE
271 0:00:09.118 209 000 0x00000785 STL R0,00(BR14) A:FCC'BOMB'RELEASE
272 0:00:09.118 210 000 0x00000552 OPRND WRITE 13504 A:FCC'LATITUDE
274 0:00:09.118 239 000 0x000007c8 STL R4,0554 A:FCC'BOMB'RELEASE
276 0:00:09.118 240 000 0x00000554 OPRND WRITE 2.002144 A:FCC'LONGITUDE
278 0:00:09.118 597 000 0x00000869 STL R0,055c A:FCC'BOMB'RELEASE
280 0:00:09.118 597 000 0x0000055c OPRND WRITE 13503.93 A:FCC'RANGE'TO'TARGET

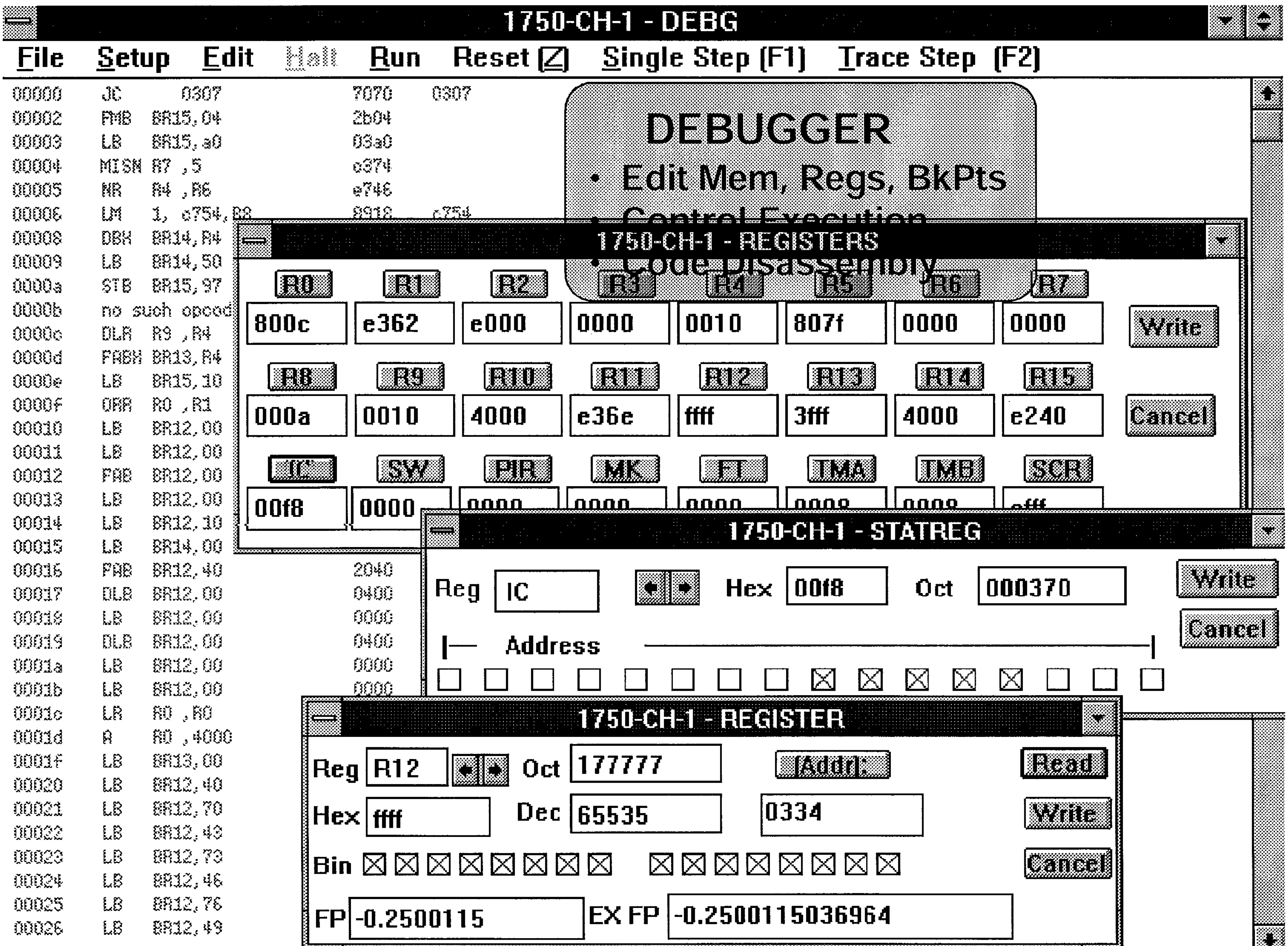
1182


STEP
File Events Graph Zoom In Zoom Out Refresh
2500
13683.94
7761.297
Graphical Plots of Variable Data Collected
1981.078
10623.962
7714.4375
1462.156
7663.964
7667.578
X-CURSOR
O-CURSOR
00:00:09.018044
00:00:34.586744
00:01:00.15544
Easy Timing Measurements with Cursors
EVENT
1 A:FCC'ALTITUDE
1 A:FCC'RANGE'TO'TAR
1 A:FCC'RANGE'OF'FAL
1 A:PILOT'CONSENT
1 A:RELEASED
CTAC time:
X-CURSOR
1470.57
7679.96
7689.68
1
1
00:00:23.933119
C-CURSOR
1470.85
7663.96
7690.4
1
1
00:00:34.586744
O-CURSOR
1470.85
7663.96
7690.4
1
1
00:00:31.518500
TIME DIFFERENCES
C - X Time: 00:00:10.653625
O - C Time: -00:00:03.068244
O - X Time: 00:00:07.585381

1183


PEP
File
Events
Graph
Zoom In
Zoom Out
Refresh
Graphical Profiling of Code Execution or Message Traffic
Easy Timing Measurements with Cursors
X-CURSOR
O-CURSOR
00:00:21.959217
00:00:22.066525
00:00:22.26403
X TIME: 00:00:21.909813
C TIME: 00:00:22.066525
O TIME: 00:00:21.958369
C-X TIME: 00:00:00.156912
O-C TIME: -00:00:00.108256
O-X TIME: 00:00:00.048556

1184

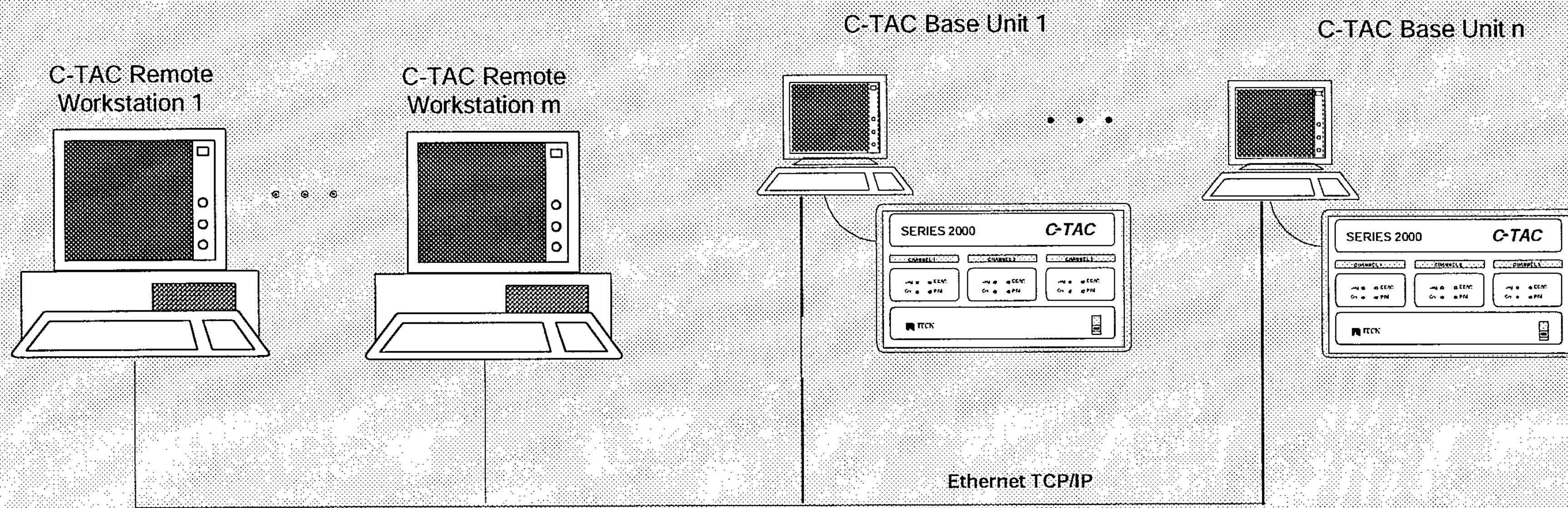

1750-CH-1 - DEBG
File Setup Edit Halt Run Reset Single Step (F1) Trace Step (F2)
00000 JC 0307 7070 0307
00002 FMB BR15,04 2b04
00003 LB BR15,a0 03a0
00004 MISN R7 ,5 e374
00005 NR R4 ,R6 e746
00006 LM 1, e754,
00008 DBX BR14,R4
00009 LB BR14,50
0000a STB BR15,97
0000b no such opcod
0000c DLR R9 ,R4
0000d FABX BR13,R4
0000e LB BR15,10
0000f ORR R0 ,R1
00010 LB BR12,00
00011 LB BR12,00
00012 FAB BR12,00
00013 LB BR12,00
00014 LB BR12,10
00015 LB BR14,00
00016 FAB BR12,40 2040
00017 DLB BR12,00 0400
00018 LB BR12,00 0000
00019 DLB BR12,00 0400
0001a LB BR12,00 0000
0001b LB BR12,00 0000
0001c LR R0 ,R0
0001d A R0 ,4000
0001f LB BR13,00
00020 LB BR12,40
00021 LB BR12,70
00022 LB BR12,43
00023 LB BR12,73
00024 LB BR12,46
00025 LB BR12,76
00026 LB BR12,49
DEBUGGER
• Edit Mem, Regs, BkPts
• Control Execution
• Code Disassembly
1750-CH-1 - REGISTERS
R0 800c R1 e362 R2 e000 R3 0000 R4 0010 R5 807f R6 0000 R7 0000
R8 000a R9 0010 R10 4000 R11 e36e R12 ffff R13 3fff R14 4000 R15 e240
IC 00f8 SW 0000 PIR MK FT TMA TMB SCR
Write
Cancel
1750-CH-1 - STATREG
Reg IC Hex 00f8 Oct 000370
Address
Write
Cancel
1750-CH-1 - REGISTER
Reg R12 Oct 177777 [Addr]: Read
Hex ffff Dec 65535 0334 Write
Bin
Cancel
FP -0.2500115 EX FP -0.2500115036964

1185

ITCN
SOLUTIONS FOR EMBEDDED SYSTEMS INTEGRATION

C-TAC COMPUTER TESTER ANALYZER CONTROLLER

C-TAC Remote Workstation Software

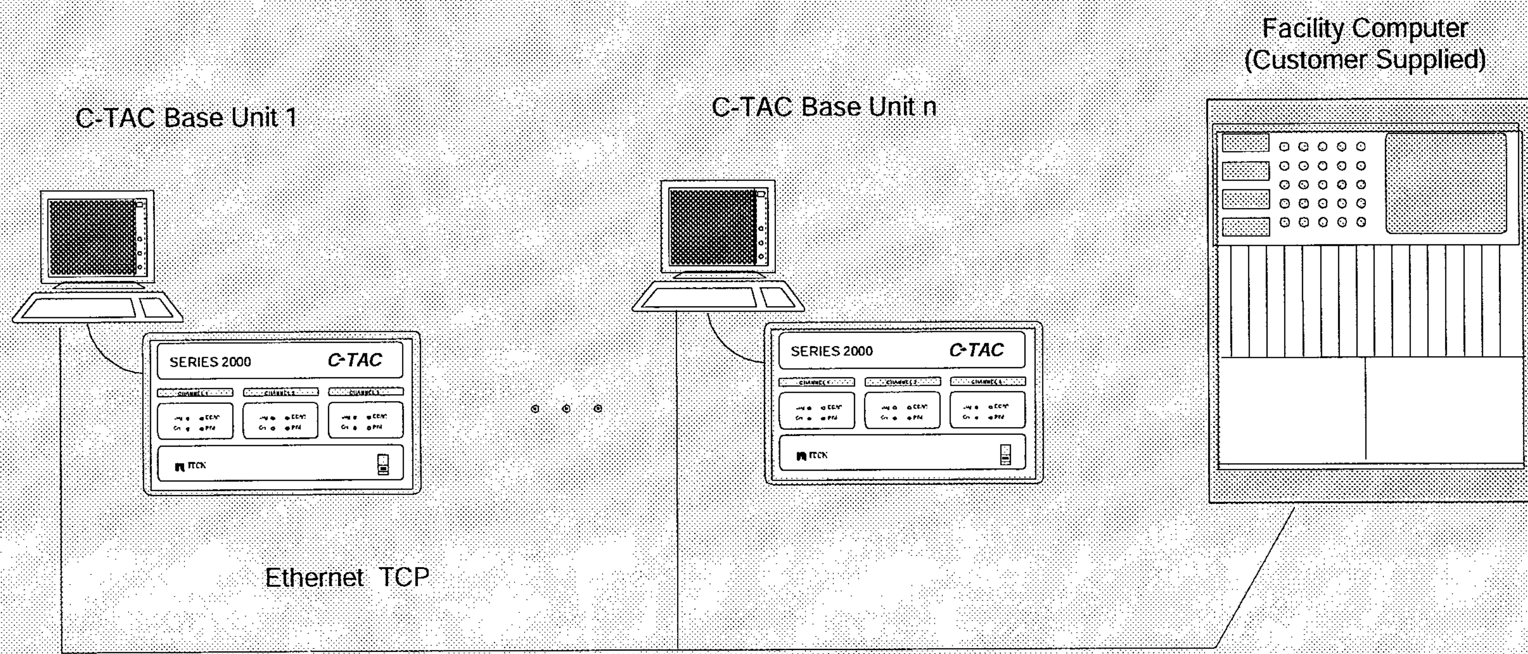


- C-TAC Base Units cannot be used as standalone units when in the Remote Mode.
- Software is provided to reconfigure the C-TAC Base Units to Standalone Mode.
- Optional C-TAC equipment required.

ITCN SOLUTIONS FOR EMBEDDED SYSTEMS INTEGRATION

C-TAC COMPUTER TESTER ANALYZER CONTROLLER

C-TAC Remote Control Software

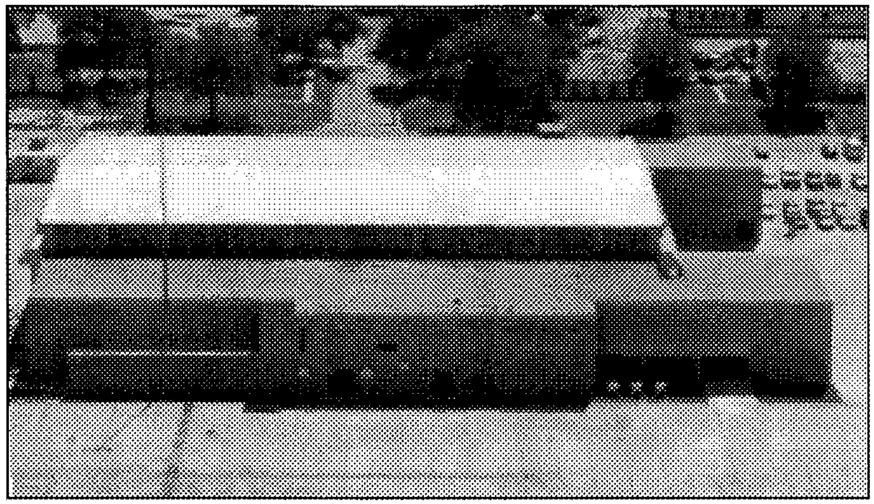


- Load C-TAC specification files
- Download to target memory
- Start / Stop monitor
- Run / Halt target
- Upload captured data
- Read / Write target memory
- Read / Write target registers

Note:

Not all commands are supported on all taragets
Optional C-TAC equipment required
Customer supplied facility computer required

PRIMES



PREFLIGHT INTEGRATION OF MUNITIONS AND ELECTRONIC SYSTEMS

46 TW/TSWW
Michael Deis
DSN 872-9354 X-222
deis@eglin.af.mil

9/1/98

TOPICS

- Facility Overview
- Sensor Passive Ranging Test Capability
- AIM-9X JHMCS Integration Test Capability
- Polarization Measurement and Simulation Test Capability
- F-15/APG-70 Radar Interface Adapter
- Target Radar Cross-Section Model
- F-15/F-16 Munitions Ballistic Modeling

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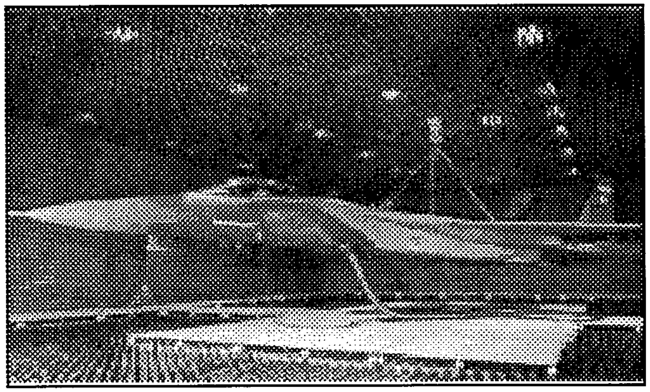
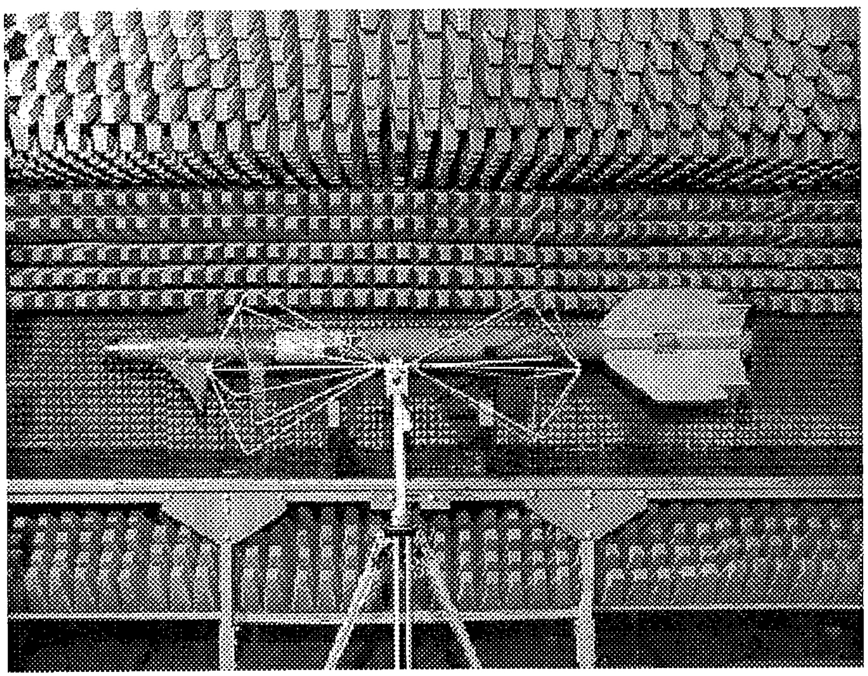
CHAMBER TESTING



- FULLY ANECHOIC WITH 74' X 104' X 26' WORKING VOLUME
  - 20' X 66' DOOR & 40 TON HOIST
- 100 dB RF ISOLATION
- FOR SYSTEM-LEVEL EMC TESTING PER MIL-E-6051, ETC
- EXTENSIVE INSTRUMENTATION FOR REMOTE MONITORING & STIMULATION OF ON-BOARD SYSTEMS
- PRIMES ADDITIONAL SUPPORT CAPABILITIES
  - EMI/EMC DESIGN AND PROGRAM SUPPORT
  - MODELING & SIMULATION/SOFTWARE DEVELOPMENT
  - CONSULTATION ON OTHER E3 DISCIPLINES SUCH AS ESD, EM HAZARDS, LIGHTNING & TEMPEST
  - OFF-SITE MEASUREMENTS SUCH AS EM AMBIENTS
- ELECTRICAL, HYDRAULIC, AIR CONDITIONING UTILITIES AVAILABLE

EMI/EMC LABORATORY



- 12' X 24' X 8' SEMI-ANECHOIC SHIELDED ENCLOSURE
  - PROVIDES UNIT OR SUBSYSTEM LEVEL EMI TESTING
  - FERRITE TILES & ANECHOIC CONES FOR LOW & HIGH FREQUENCY ATTENUATION
  - 16' COPPER-TOPPED TEST BENCH AND FILTERED POWER
- NVLAP ACCREDIATION THROUGH NIST, NARTE CERTIFIED EMC ENGINEER
- RADIATED/CONDUCTED EMISSIONS & SUSCEPTIBILITY
- ESTABLISHED FOR MIL-STD-461/-462 TESTING
  - CAPABILITIES ENCOMPASS MANY OTHER EMI SPECS
  - RADIATED CAPABILITIES FROM 30 Hz TO 40 GHz

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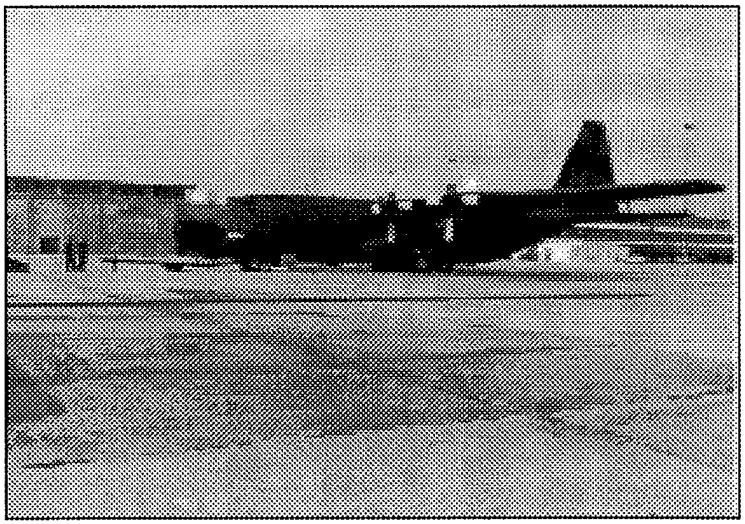
LARGE AIRCRAFT RAMP TESTING



- OUTDOOR TEST AREA
- RADIATED TESTING AVAILABLE
- ACCESS TO ALL FACILITY SIMULATION AND INSTRUMENTATION CAPABILITIES
- ANTENNA PATTERN MAPPING

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SENSOR PASSIVE RANGING TEST CAPABILITY

- Dynamic line-of-sight target simulation
- RF, 0.5-20 GHz, radiated free space simulation
- Supports aircraft sensor and munitions seeker tests
- 6 degree-of-freedom target and sensor motion
- Measures passive ranging algorithm performance
- Supports situation awareness and sensor fusion
- Parallax error compensation

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AIM-9X JHMCS INTEGRATION TEST CAPABILITY

- 6 DOF motion simulation of F-15 and the missile target
- Visual cueing to target aircraft
  - Laser spot on ceiling and side walls of chamber
  - Represents the LOS angle from cockpit to target
- Fire control radar cueing performance
- Missile umbilical instrumentation
- EMI/EMC system testing
- GWEF-PRIMES Link

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POLARIZATION MEASUREMENT AND SIMULATION TEST CAPABILITY

- RF, 0.5-20 GHz, radiated free space
- Measures all polarization parameters of antennas
- Simulates all polarization characteristics of antennas
- Tests next generation receivers and antenna discriminates
- Tests DF sensitivity of monopulse antennas

F-15/APG-70 RADAR INTERFACE ADAPTER

- Timing signal interface between APG-70 radar and PRIMES target generator
- Will support Suite 3 & 4 OFP tests
- Funded by F-15 program office ($800K)
- Design upgrade path for APG-63V1 interface

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TARGET RADAR CROSS SECTION MODEL

- CAD-based, ray analysis model
- 10 GHz target frequency at far-field range
- Database model for PRIMES target generator
- Target models include QF-4E and blue fighters

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F-15/F-16 MUNITIONS BALLISTIC MODELING

- Tests CCIP and CCRP avionics functionality
- Will support F-16 Block 40 Tape 6 tests
- Initial models include MK-82 AIR, MK-82 and PGU-28
- Tests SMS and PACS functionality
- Test EGS functionality

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ELECTRONIC COMBAT INTERNATIONAL
SECURITY ASSISTANCE PROGRAM

ECISAP
WR-ALC/LNI

<u>Presented by:</u>

Mike Morris

WR-ALC/LNIE

LNI MISSION ORIENTATION
ECISAP MISSION

WARFIGHTERS

PLANNING

DEVELOPMENT

SUSTAINMENT

EW REPROGRAMMING	REPAIR	MODS/TECH INSERTION
PROGRAM MANAGEMENT	ENGINEERING	LOG MANAGEMENT

ECISAP

- Structure
- Mission
- Staffing
- Facilities
- Advantages

ECISAP
STRUCTURE

- USAF Management Concept
  - *EC single management focal point*
  - *Initial installation & follow-on support*
  - *EW standardization and interoperability for ECISAP member nations*
- Managed by SAF/IA
  - *USAF International Affairs oversight*
  - *AFI 10-703*
  - *AFMAN 16-101*

ECISAP
STRUCTURE

- ECISAP Executive Agent: WR-ALC/LNI (International Logistics Division, Electronic Warfare Directorate)
  - ***Coordinate ECISAP efforts among key administering agencies such as:***
    - AF/XOIO HQ ACC/DOSS
    - SAF/IA 68 ECG
    - AFSAC AFIWC
    - AF/XOIIF AFSAT
    - Other agencies as determined by the LOA

ECISAP
STRUCTURE

- Executive Agent (continued)
  - ***Coordinate Pricing & Availability (P&A) data and Letter of Agreement (LOA) input***
    - Establish Military Articles and Services List (MASL) line item on system sale LOA
    - Individual LOA
- Two Types of Membership
  - ***Full service (software and hardware)***
  - ***Technical Support only***

ECISAP
MISSION

- Single Focal Point for EC FMS and Security Assistance Systems
  - *Initial (pre-aircraft delivery)*
  - *Follow-on (post-aircraft delivery)*

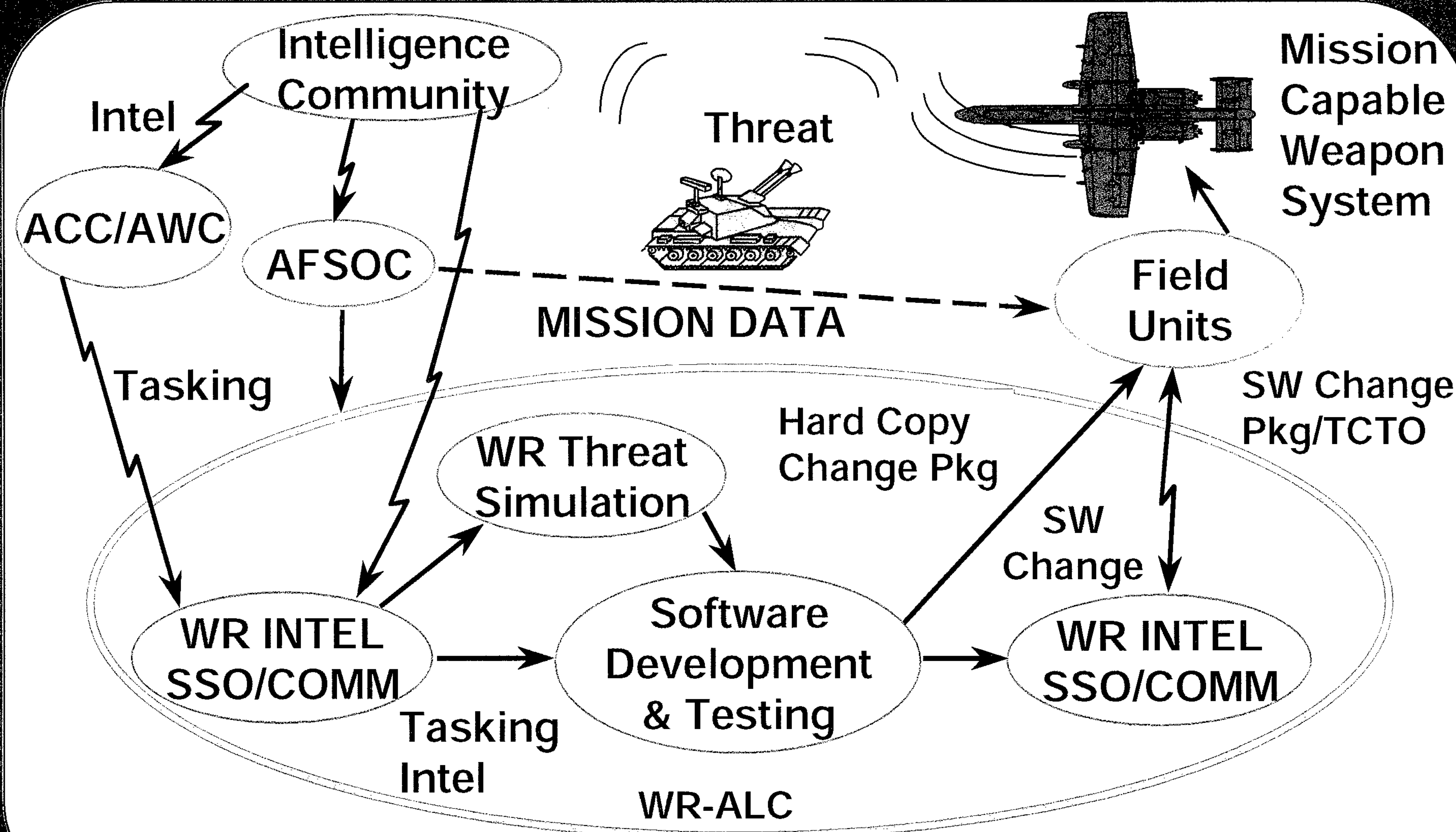
ECISAP
MISSION

- Provide System Support
  - *Hardware deficiencies/enhancements*
- Provide System Software Support
  - *Operational Flight Program*
  - *Mission data or threat data*
- Provide Rapid Reprogramming Capability

ECISAP
MISSION

- Provide Technical Services and Assistance
- Provide Country Standard Technical Orders
- Provide Configuration Management
- Provide Kitproofing of Software Updates

ECISAP
EW SOFTWARE CHANGE CYCLE



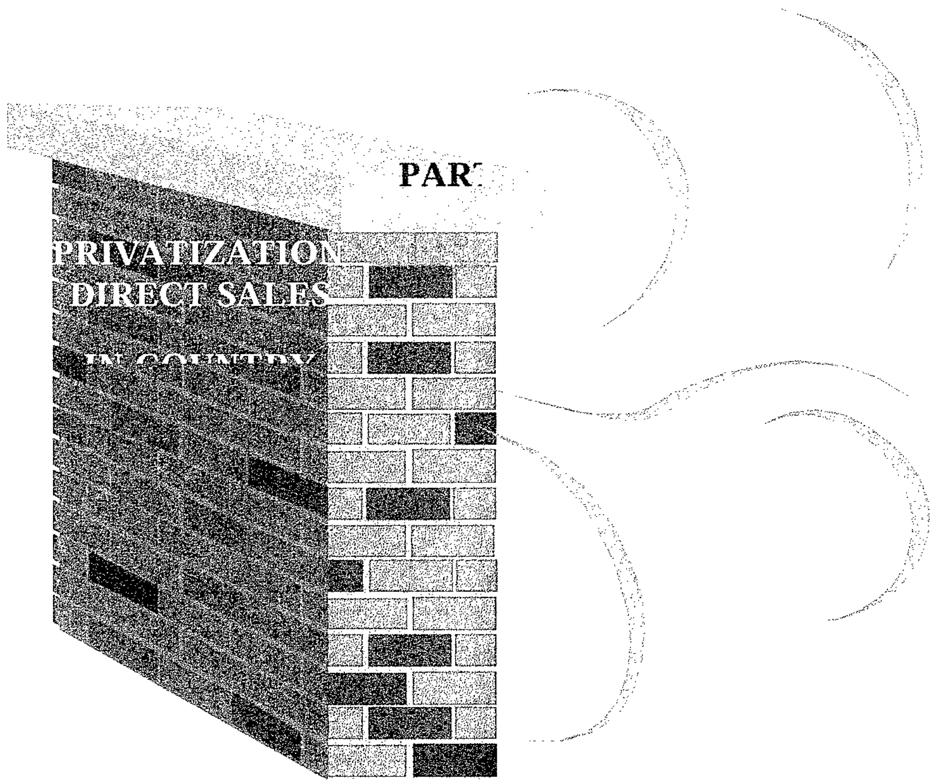
Emergency Reprogramming + Routine Block Cycle Updates

ECISAP/LNI APPROACH

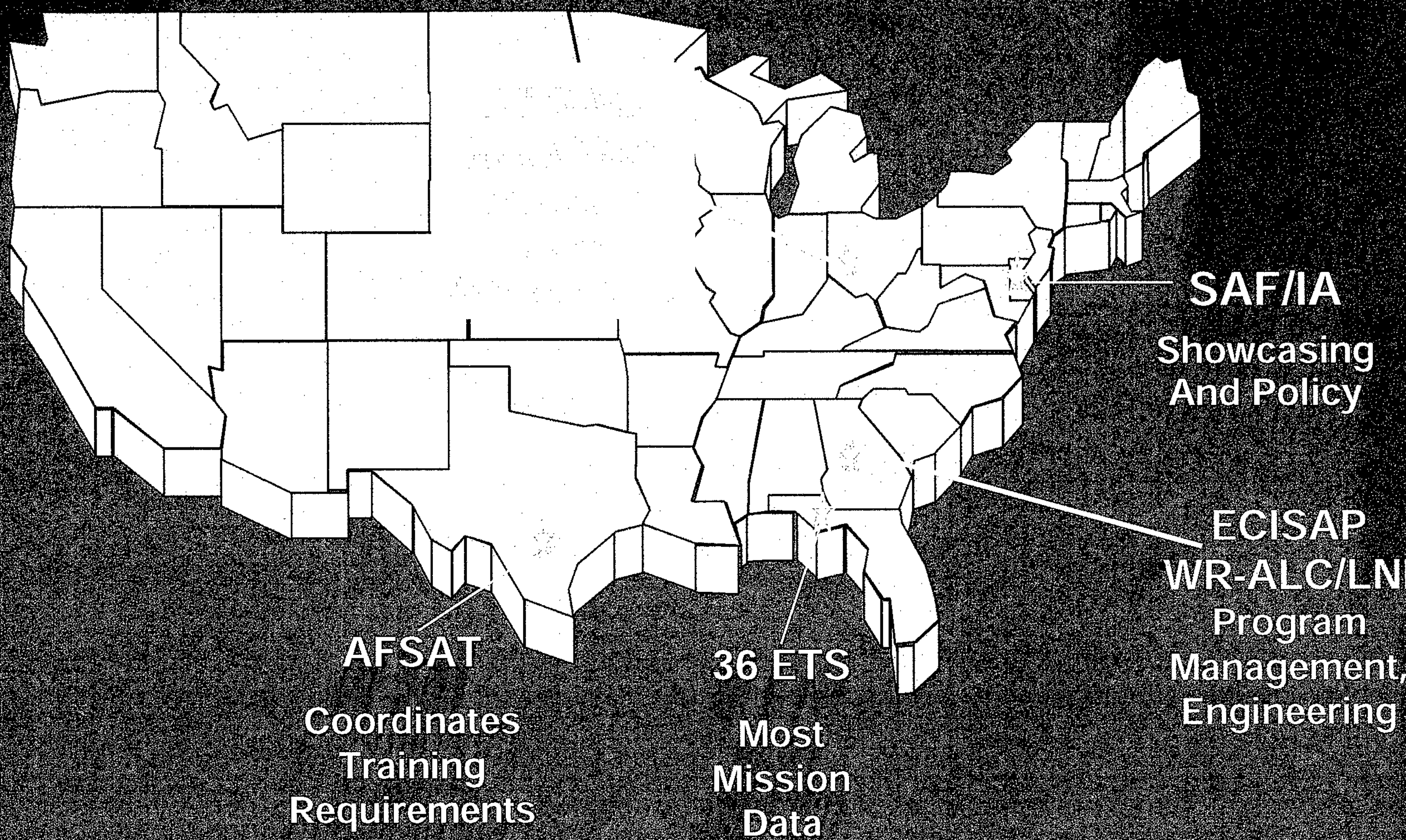
LNI's INDIRECT APPROACH

VISION --

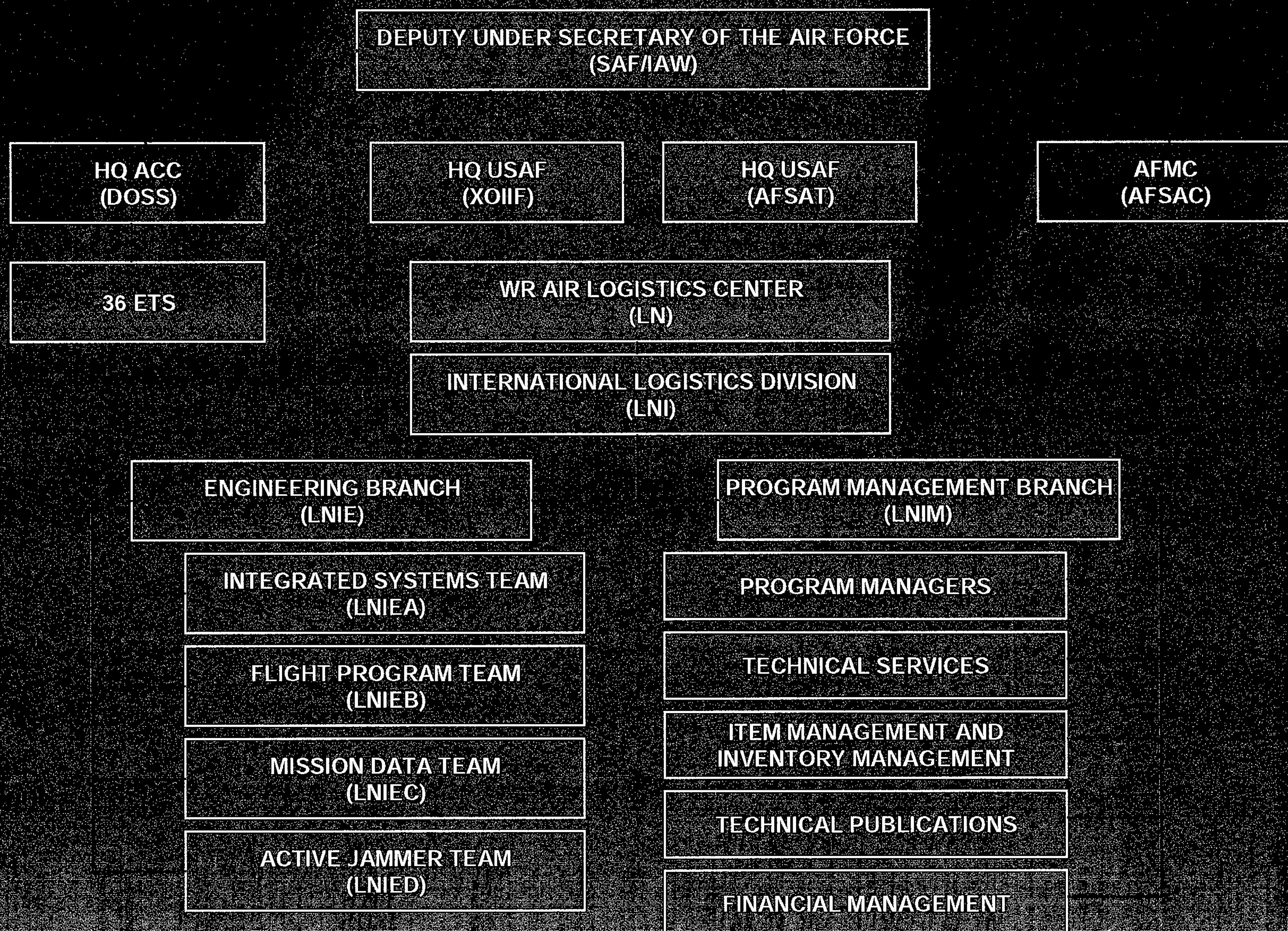
To Become The



ECISAP
FUNCTIONAL SNAPSHOT



ECISAP ORGANIZATION

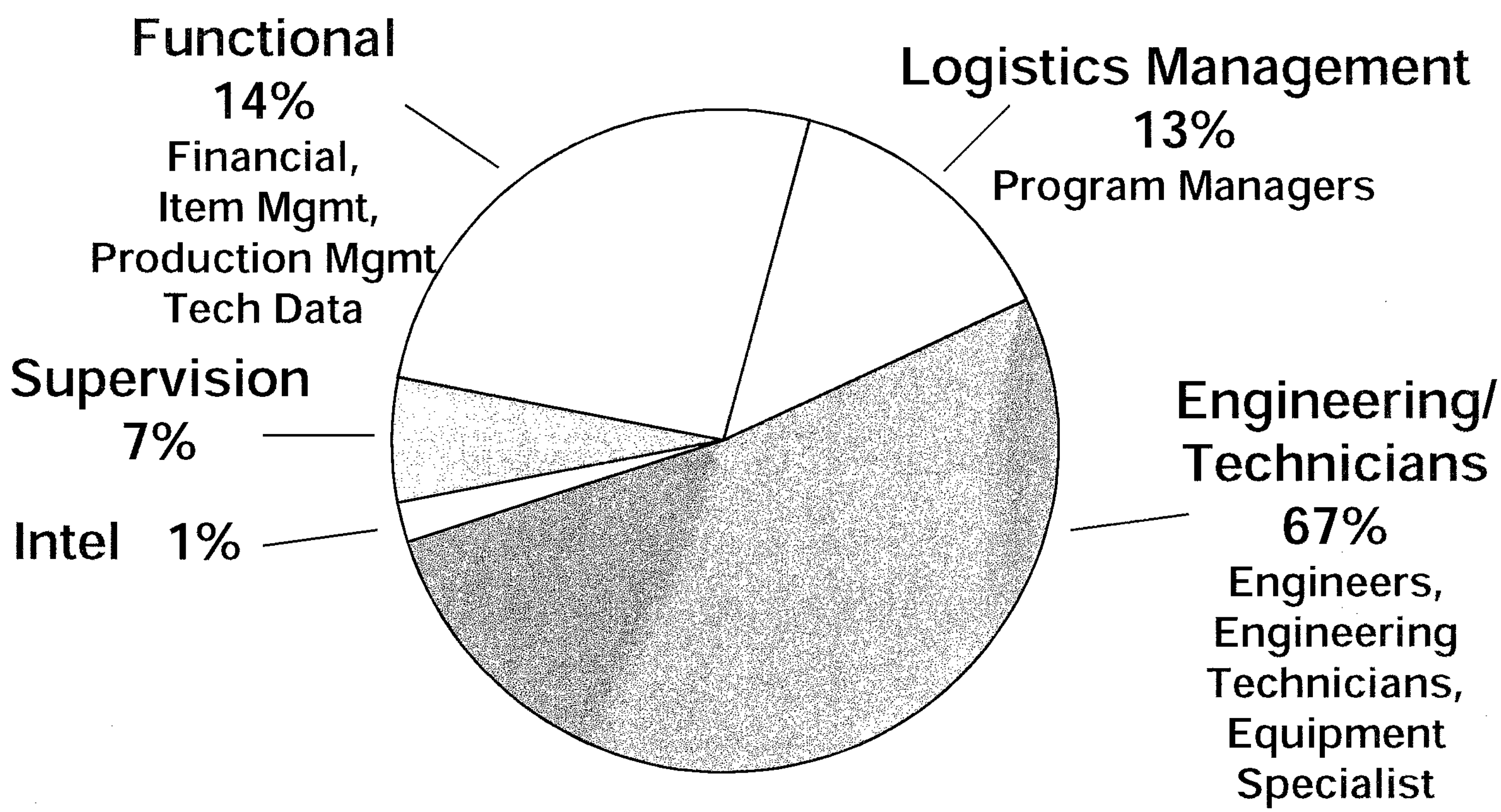


ECISAP/LNI
STAFFING

- 92 Civilians/ 5 Contractors
  - *Engineering* (GS-855s, GS-856s, GS-854s)
  - *Program Management* (GS-346s, GS-1670s, GS-2010s, GS-1087s, GS-344s)
  - *Financial Management* (GS-501s, GS-510s, GS-301s)

ECISAP/LNI
STAFFING

AUTHORIZATIONS	92
CONTRACTORS	5
PALACE ACQUIRE	1
TOTAL EMPLOYEES	98



ECISAP/LNI
FACILITIES

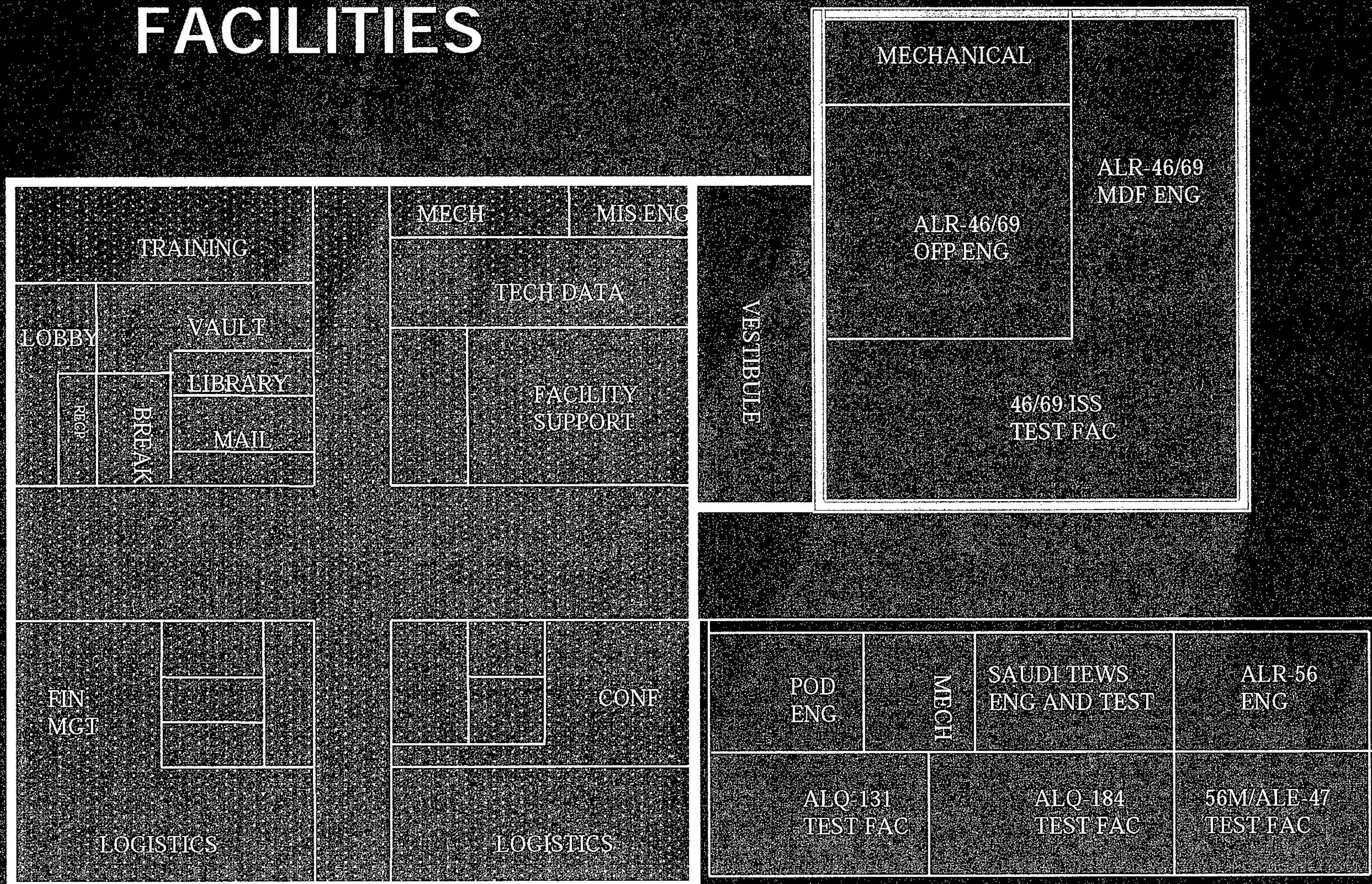
- NEARLY 43,000 SQ.FT. ELECTRONIC/COMPUTER WORK AREA (SECURE, TEMPEST & EMERGENCY POWER)
- 1 SCREEN ROOM
- SPECIAL ACCESS VAULT
  - Intelligence Data
  - Secure Communication Links
- 7 UNIQUE SYSTEM LABORATORIES
- 8 THREAT GENERATORS AND INTEGRATED SUPPORT STATIONS

✓ OVER $30M INVESTMENT

✓ MOST CAPABLE AND PRODUCTIVE FMS EW FACILITY IN DOD

ECISAP/LNI FACILITIES

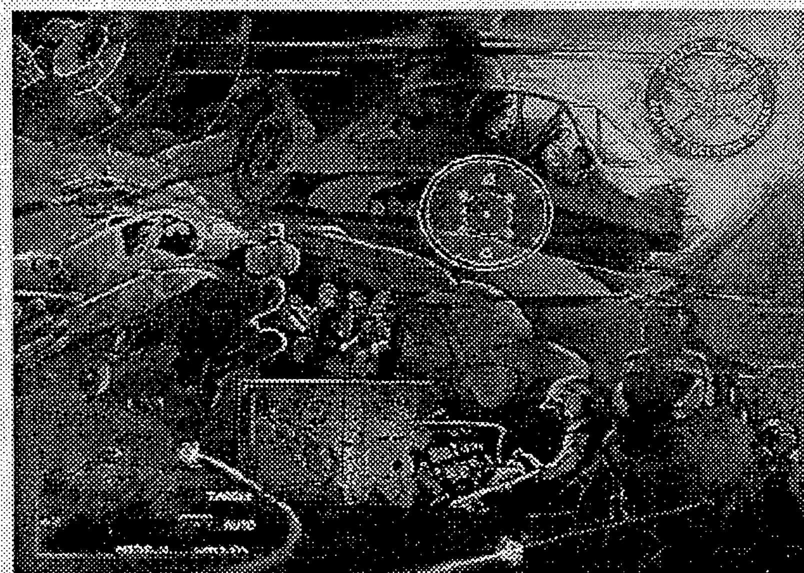
FACILITIES



ECISAP
"TOP TEN" Advantages

- ECISAP Executive Agent/ Single POC for FMS
- Rapid Reprogramming
- USAF Made and Tested Standards
- US Government Intel Data Base
- Total System Support
- Dedicated Resources
- "At Cost" Services
- In-House Technical Publications
- On-site Depot Repair
- Established Capability for 2 Decades

Program Overview



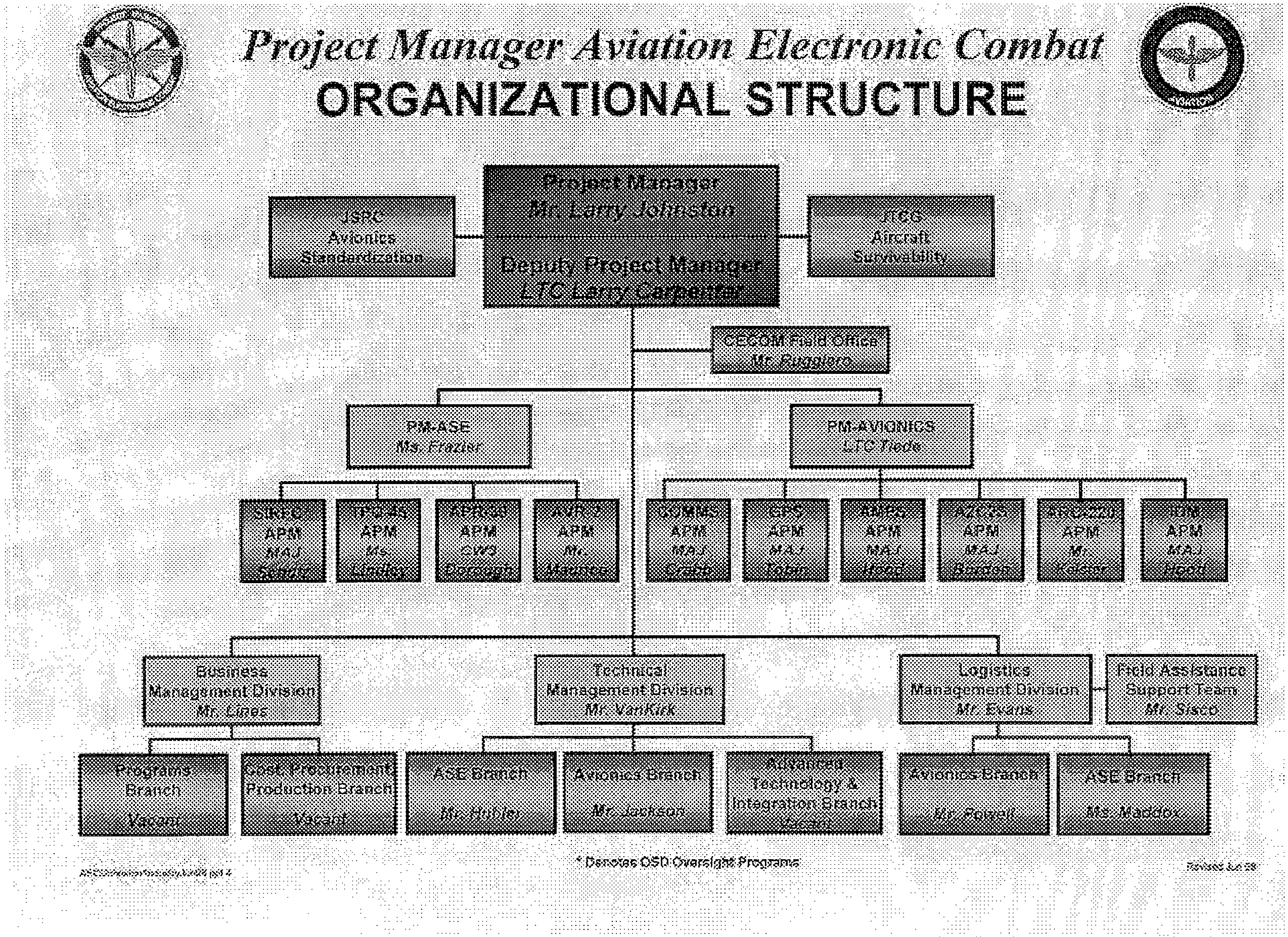
Mr. Larry D. Johnston

PROJECT MANAGER

AVIATION ELECTRONIC COMBAT

Vision

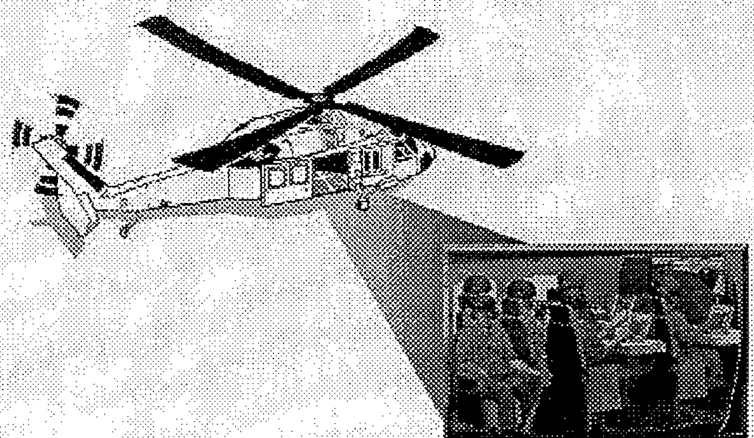
Provide the mission area leadership for determining the future technology direction and architecture for aviation electronics, while developing and producing the most capable, sustainable, and cost effective solutions for the warfighter.



Project Manager Aviation Electronic Combat
ORGANIZATIONAL STRUCTURE
Project Manager
Mr. Larry Johnston
Deputy Project Manager
LTC Larry Carpenter
JSPC
Avionics
Standardization
JTCG
Aircraft
Survivability
CECOM Field Office
Mr. Ruggiero
PM-ASE
Ms. Frazier
PM-AVIONICS
LTC Tiede
APM
MAJ
APM
Ms.
Lindley
APM
CW3
Dorough
APM
Mr.
COMMS
APM
MAJ
Crabb
GPS
APM
MAJ
Tobin
APM
MAJ
Hood
APM
MAJ
ARC-220
APM
Mr.
IDM
APM
MAJ
Hood
Business
Management Division
Mr. Lines
Technical
Management Division
Mr. VanKirk
Logistics
Management Division
Mr. Evans
Field Assistance
Support Team
Mr. Sisco
Programs
Branch
Vacant
Cost, Procurement
Production Branch
Vacant
ASE Branch
Mr. Hubler
Avionics Branch
Mr. Jackson
Advanced
Technology &
Integration Branch
Vacant
Avionics Branch
Mr. Powell
ASE Branch
Ms. Maddox
* Denotes OSD Oversight Programs

Avionics

Army Airborne Command & Control System (A2C2S)



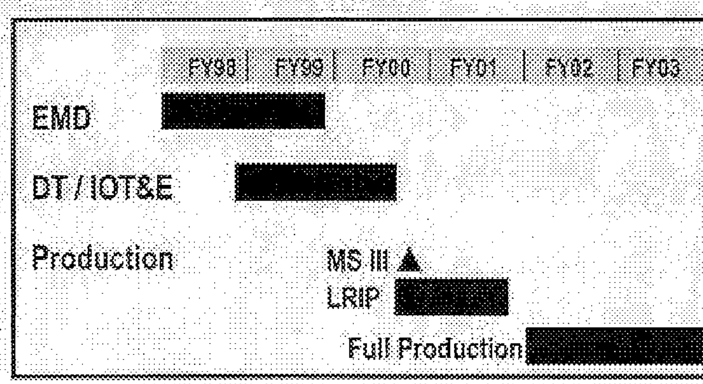
Description

- Integrated on a UH-60 Blackhawk
- AAO 207 systems, 276 A kits
- Open systems architecture
- Five reconfigurable workstations
- Weight: 1200 lbs (Obj), 1800 lbs (threshold)

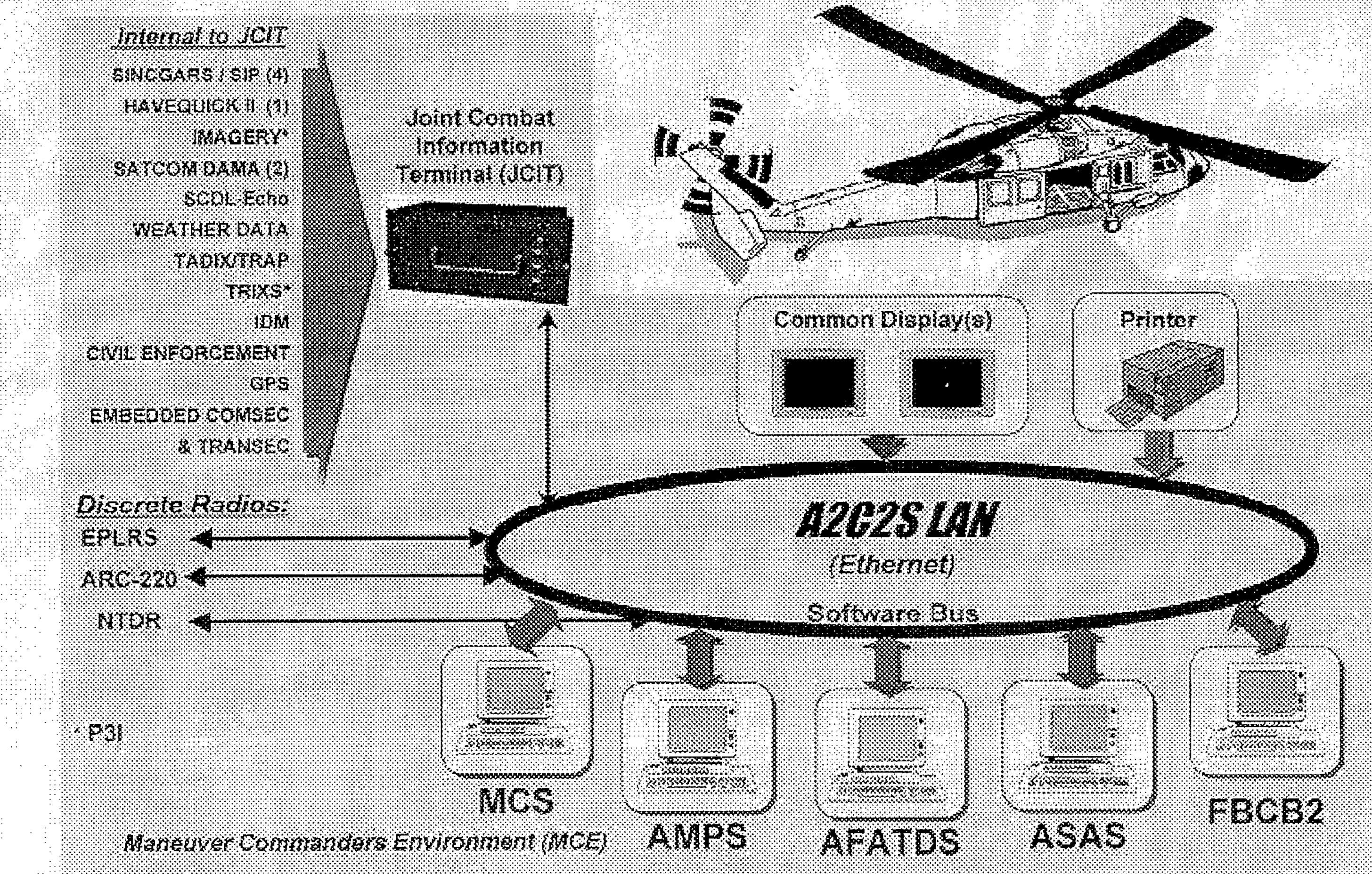
Capabilities

- Airborne Tactical Command Post
  - Automates decision support systems
  - Visual displays shorten sensor to shooter decision cycle
  - Provides situational awareness through C^4I digital connectivity
- Interoperable with other C2 systems

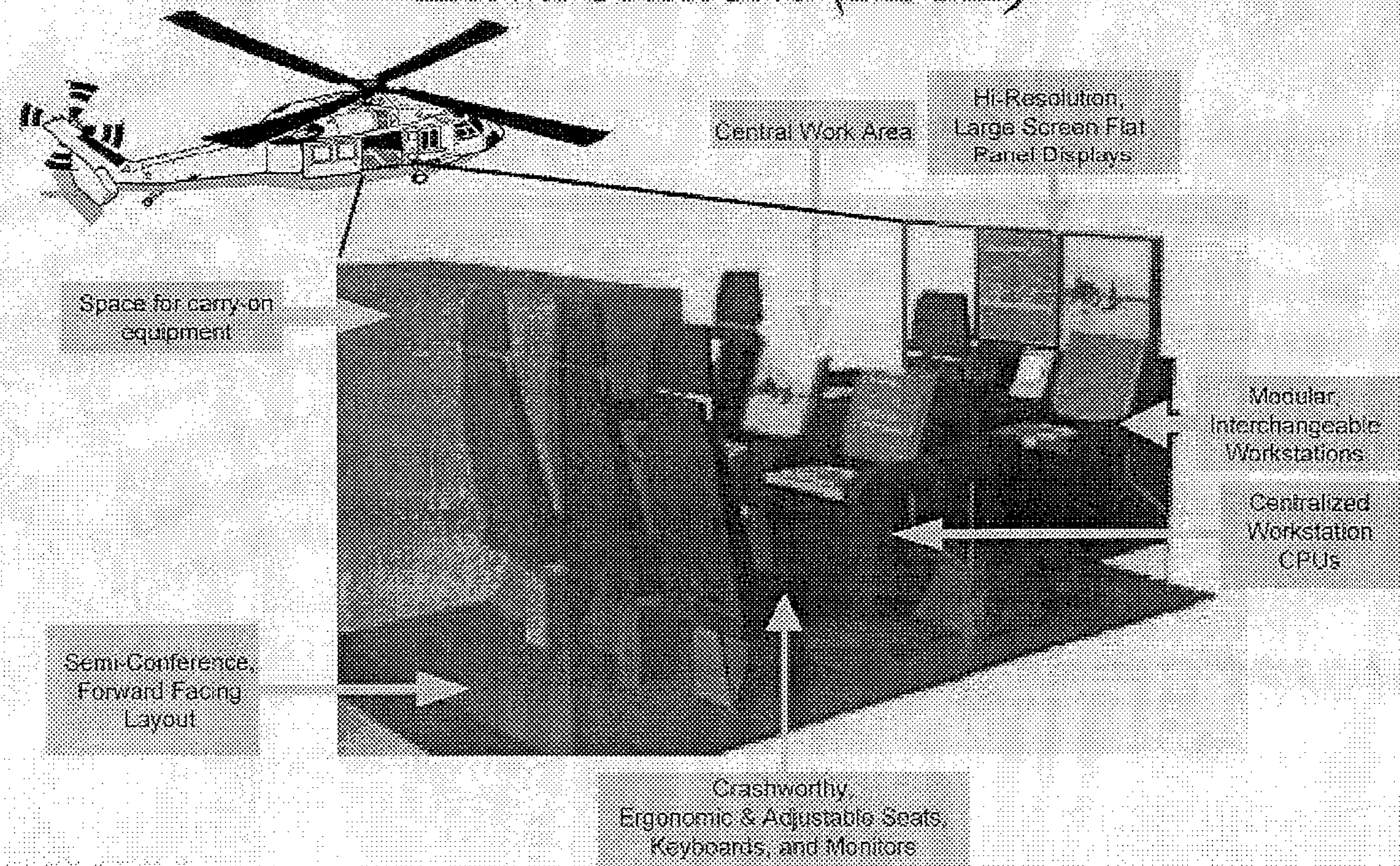
Schedule



A2C2S Top-Level Architecture

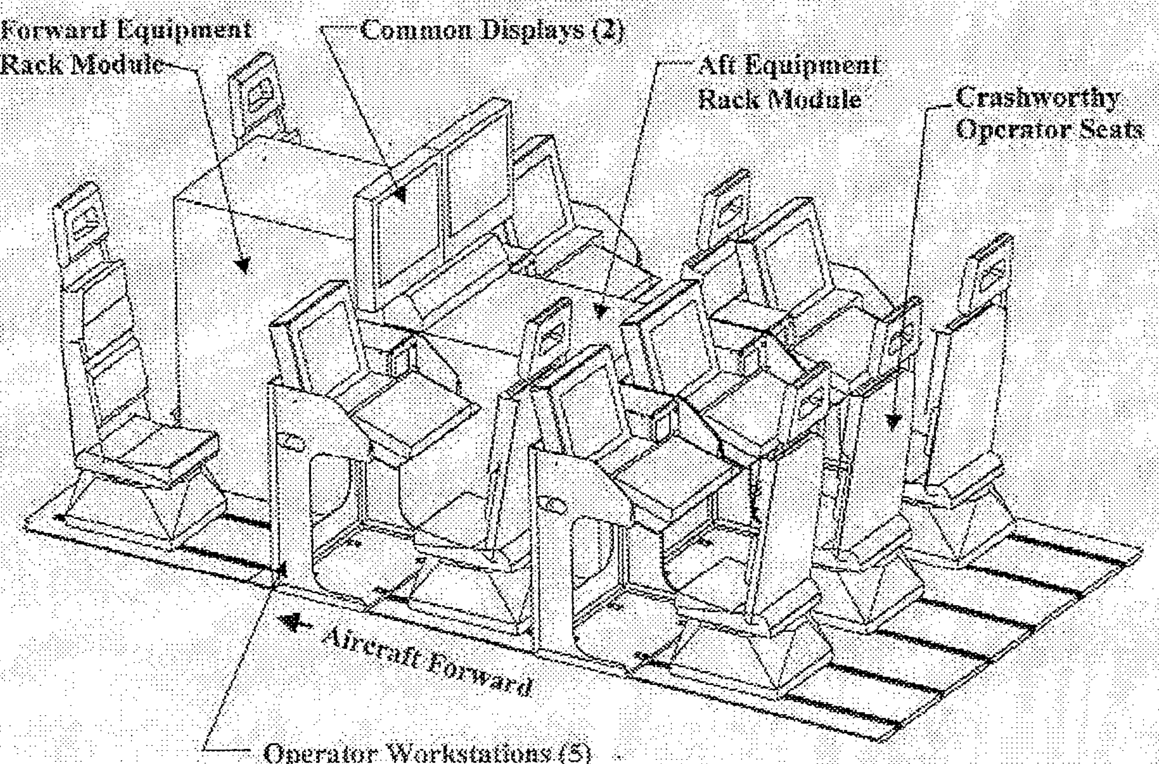


A2C2S Maneuver Commander's Environment (MCE)

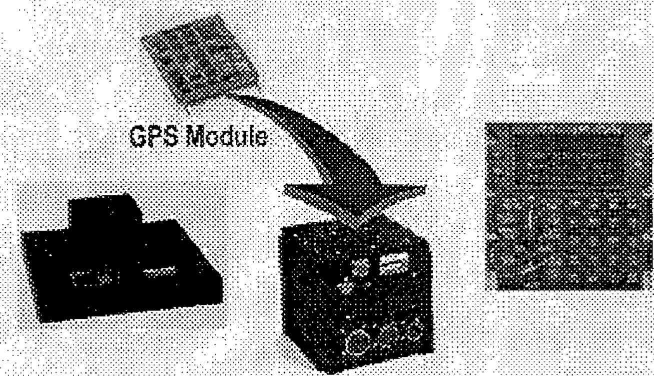


1223

A2C2S Maneuver Commander's Environment (MCE)



Doppler GPS Navigation System (DGNS)



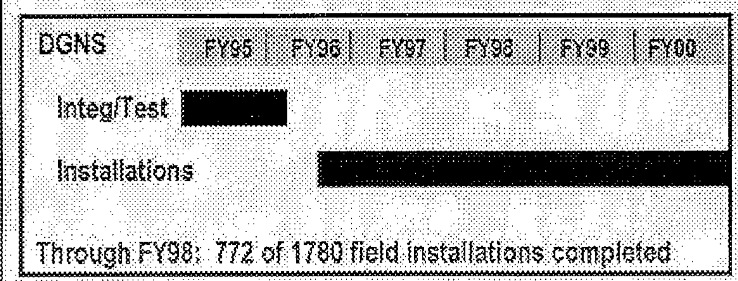
Description

- Doppler Embedded GPS (DGNS)
  - Modified Doppler system
  - UH60/CH47
  - GPS module embedded in SDC
  - Can operate in either bussed or non-bussed integrations
  - Pure Doppler, GPS-only, and mixed navigation modes

Capabilities

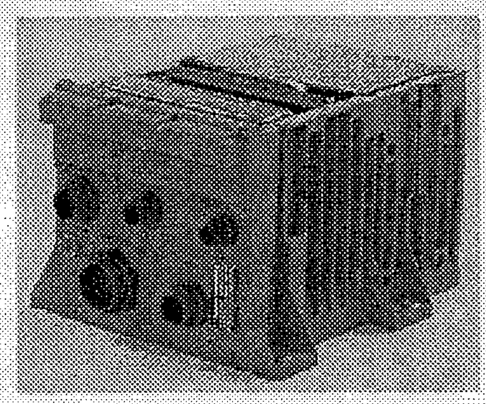
- Utilize military P(Y) code
- Integrated with flight instruments
- Precise location (16m accuracy)
- 100 waypoints - AMPS loaded
- Universal timing
- GPS approach capability
- 4-line display, new controls

Schedule



1225

Embedded GPS - Inertial (EGI)



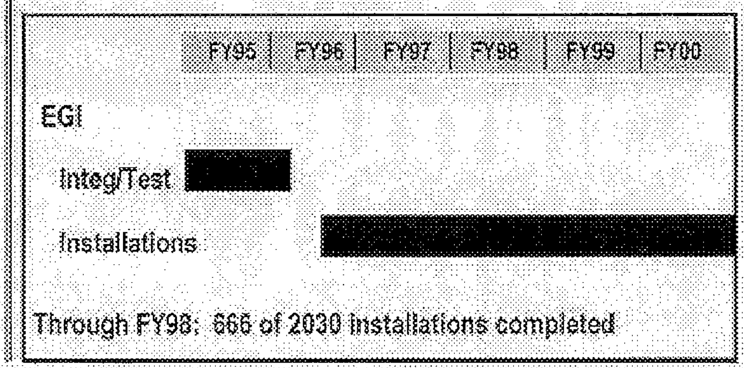
Description

- Embedded GPS Inertial (EGI)
  - 1553 Bus compatible
  - AH64A/D, OH58D, MH60K/L, MH47D/E, numerous AF, Navy aircraft
  - High MTBF: 6500 hours
  - Pure inertial, GPS-only and blended navigation modes

Capabilities

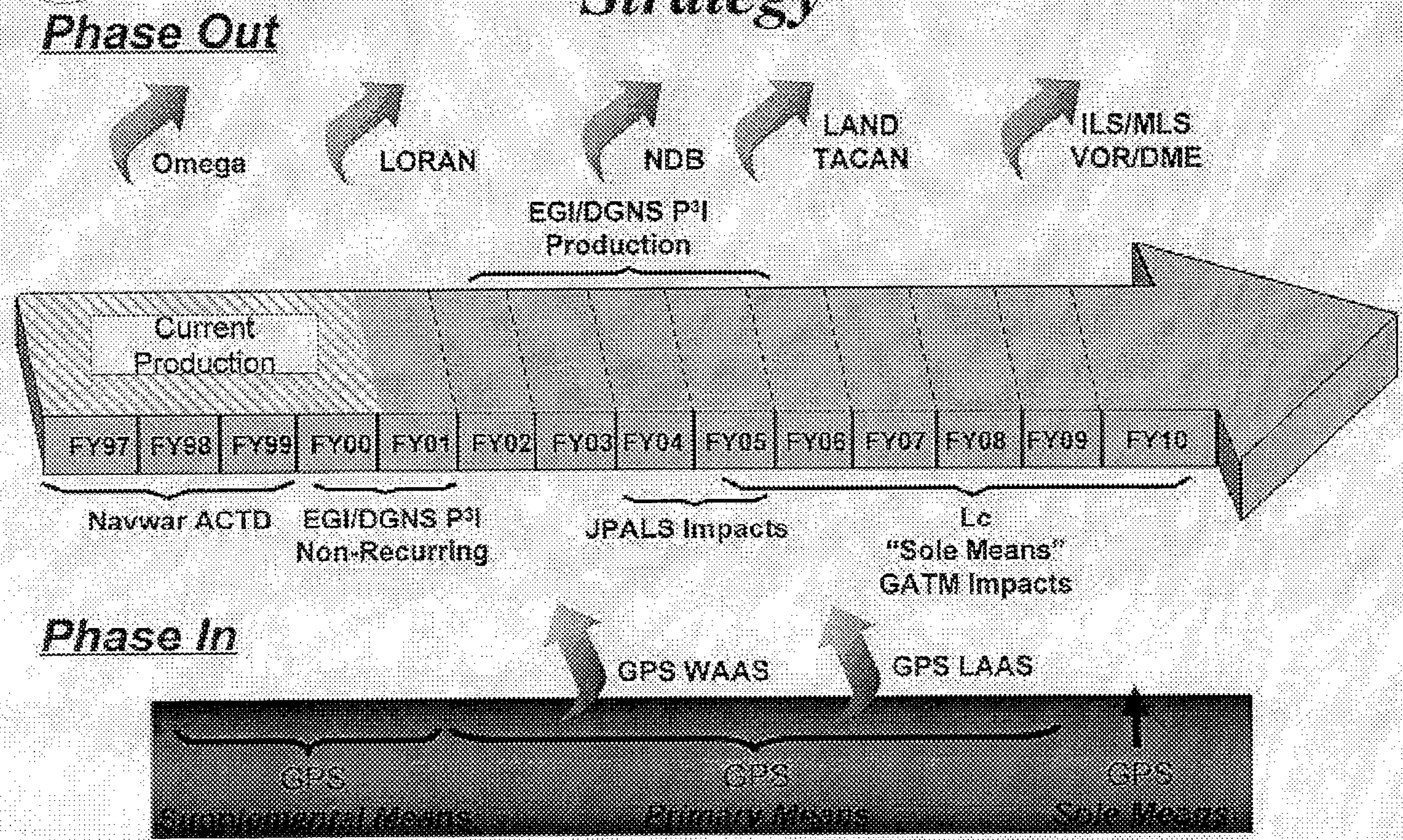
- Utilize military P(Y) code
- Precise location (16m accuracy)
- Precise velocity (INS - .8 m/s)
- Universal timing
- Integrated with on-board systems
  - Target acquisition
  - Situational awareness

Schedule



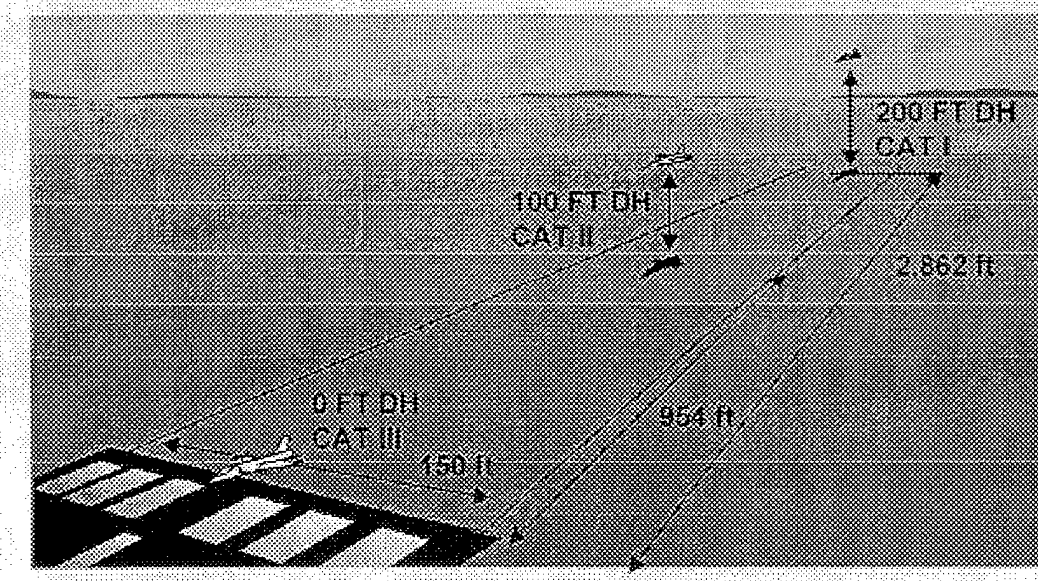
1296

NAVWAR / JPALS / GATM
Strategy



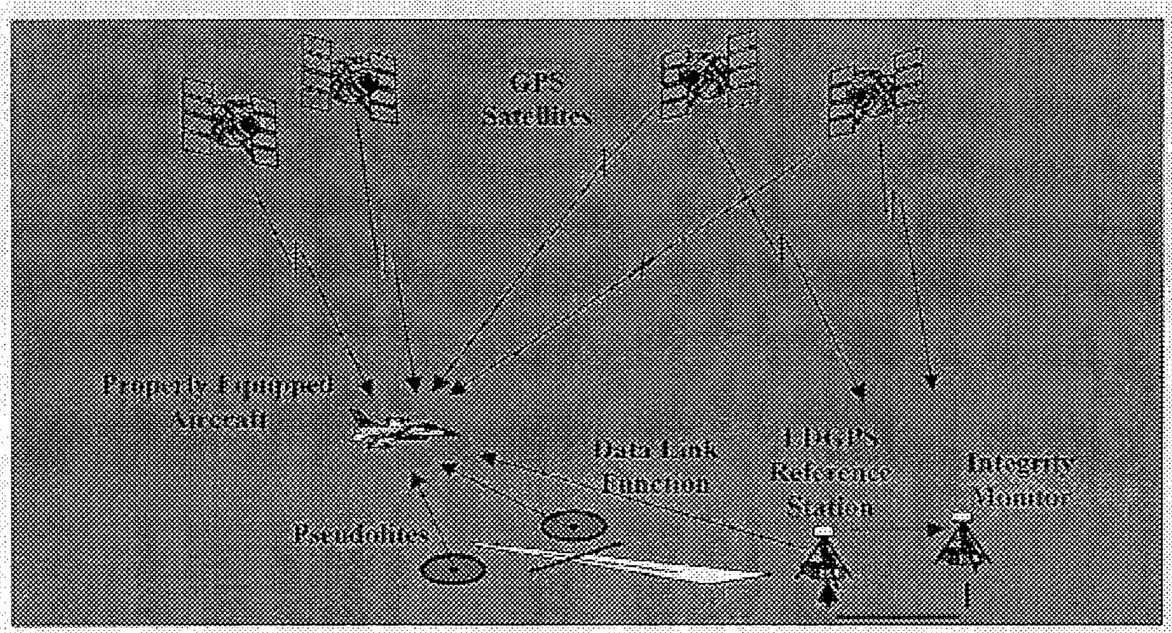
JPALS

The JPALS requirement is for a rapidly deployable, adverse weather, adverse terrain, survivable, maintainable, and interoperable precision approach and landing system (on land and sea) that supports the warfighter when ceiling and visibility are limiting factors.



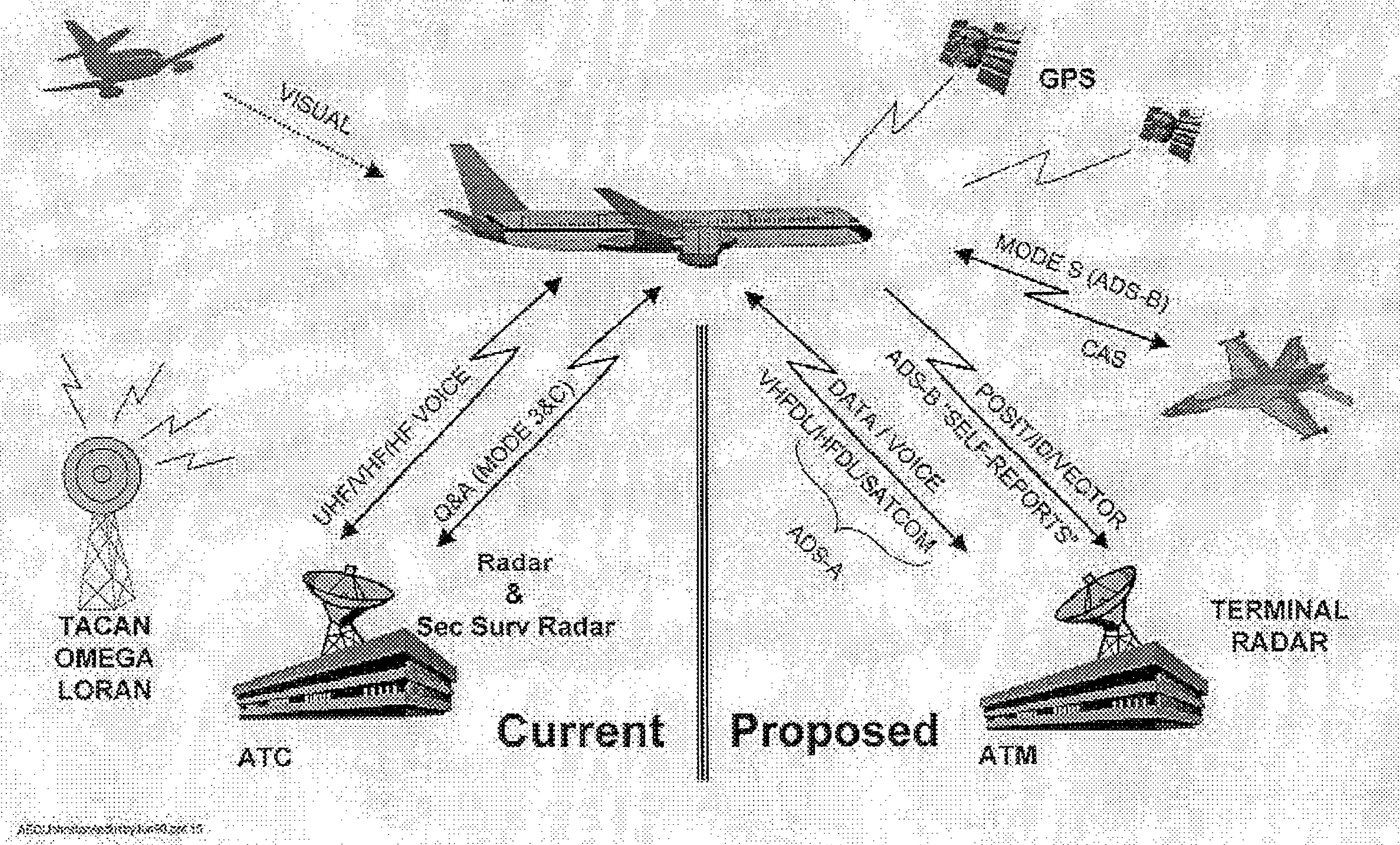
GPS Local Area Differential System
(Notional)

- AoA completed 30 Aug 97
- Local Area Differential (LDGPS) determined to be most promising solution
- ACLS+ provided best shipboard redundant capability



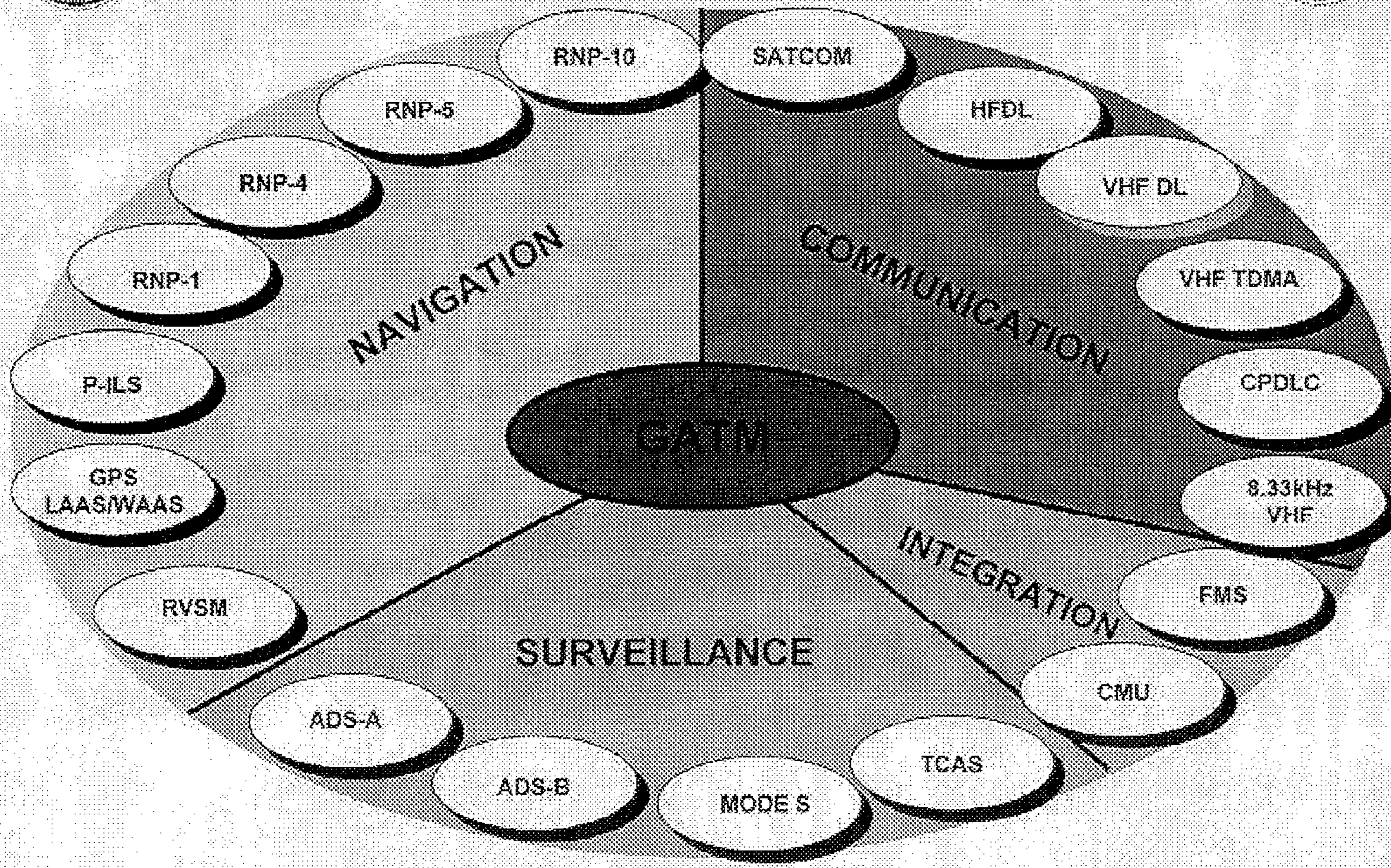
1229

Global Air Traffic Management
Communications, Navigation, Surveillance

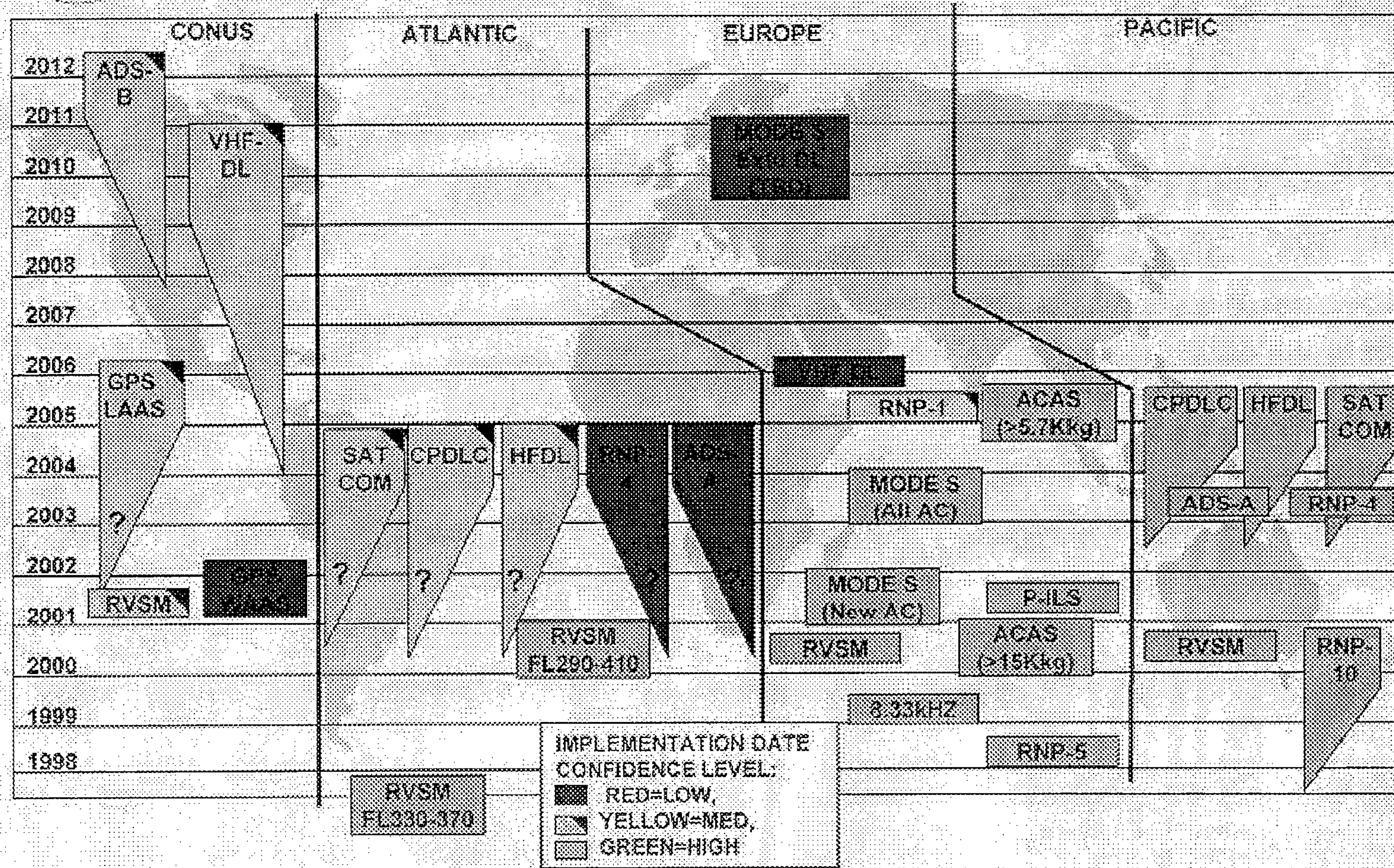


1232

The GATM Universe

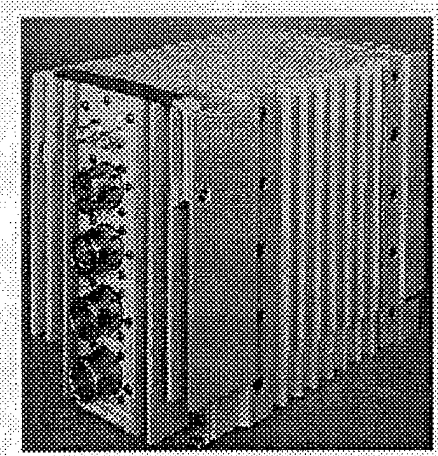


GATM Requirements Schedule



1232

Improved Data Modem (IDM/EBC)



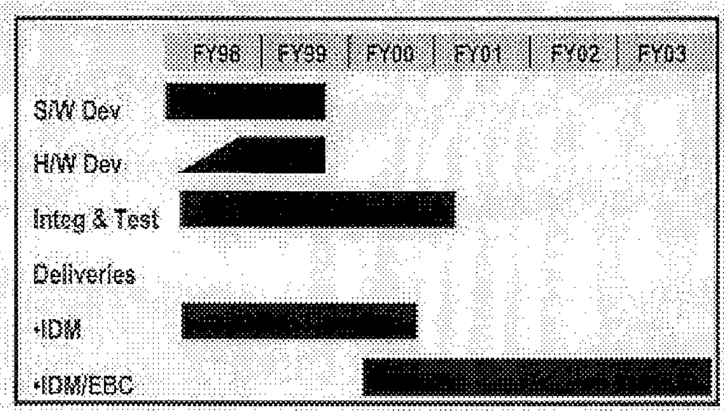
Description

- Four channel transmit/receive terminal
  - Each channel capable of analog, digital, or digital secure operations
- Processes multiple protocols and message sets (AFAPD, JVMF, AFATDS)
- Embedded battle command
  - Pentium processor, 32mb RAM, 100mb mass memory

Capabilities

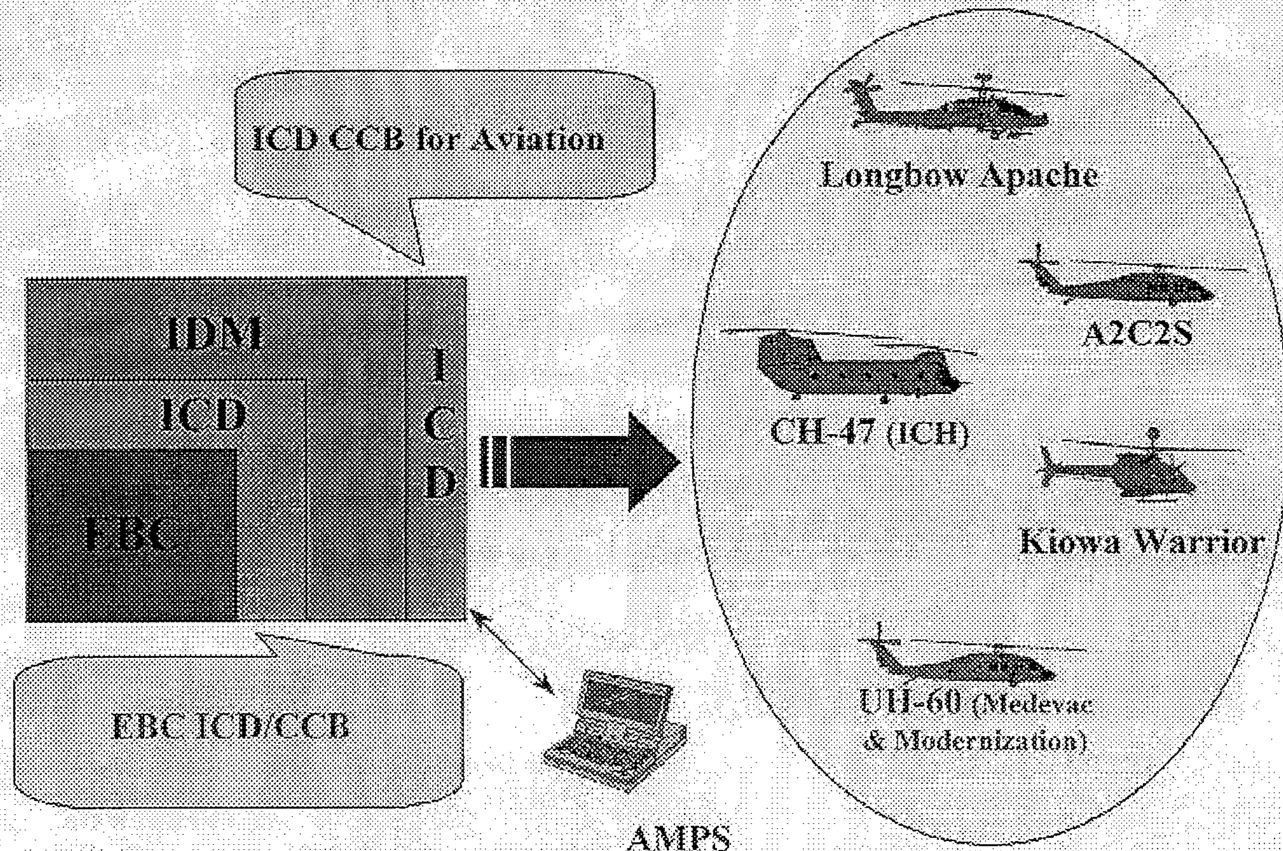
- Common multi-service aviation modem
- Provides message buffering
- Performs as aviation's Internet Controller (INC)
- Hosts EBC software to assure battlefield connectivity
- Protects mission computers from changes to message formats

Schedule

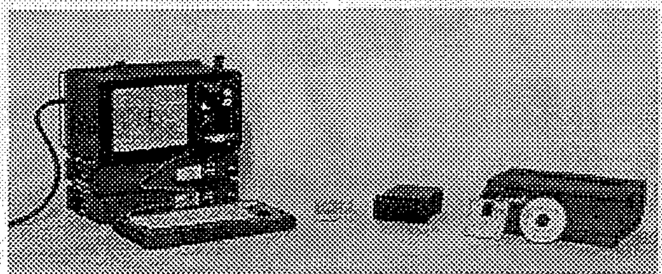


1233

EBC-IDM Platform Interface



Aviation Mission Planning System



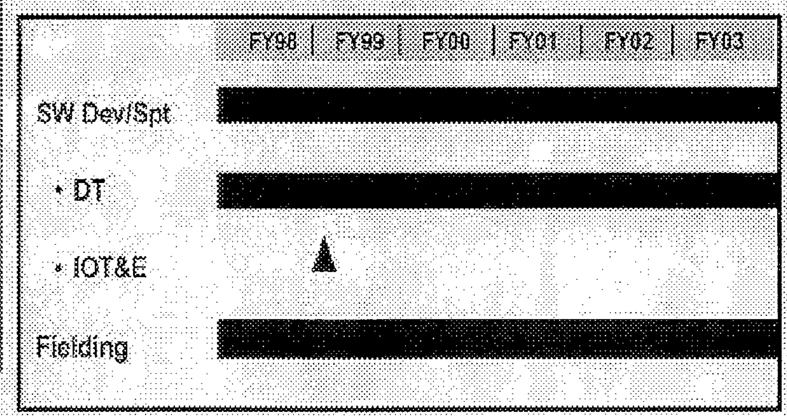
Description

- Planning/battle synchronization tool, which automates aviation mission planning tasks
  - Route generation
  - Performance planning
  - Communications planning
  - Terrain analysis
  - Data transfer
- Acquisition strategy follows evolutionary acquisition guidance
- BOIP: 2 per Avn Bde/Bn HQ, 1 per line Avn Co/Trp

Capabilities

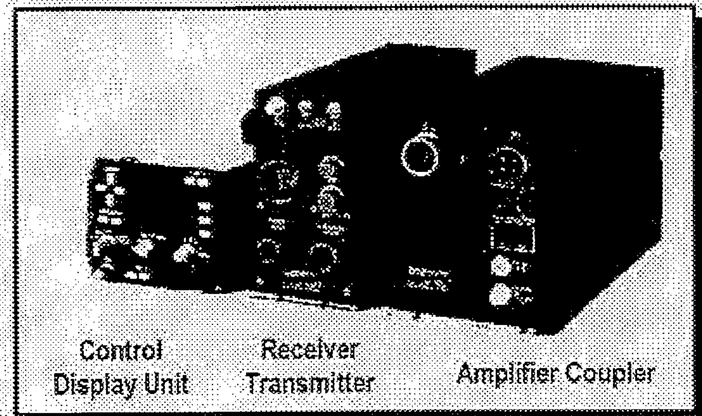
- Overlays / Military Symbols
- Hazards Locations
- Threat Intervisibility
- Operations Order Preparation
- Route / Aircraft Performance Planning
- Reduced Mission Planning Time

Schedule



1233

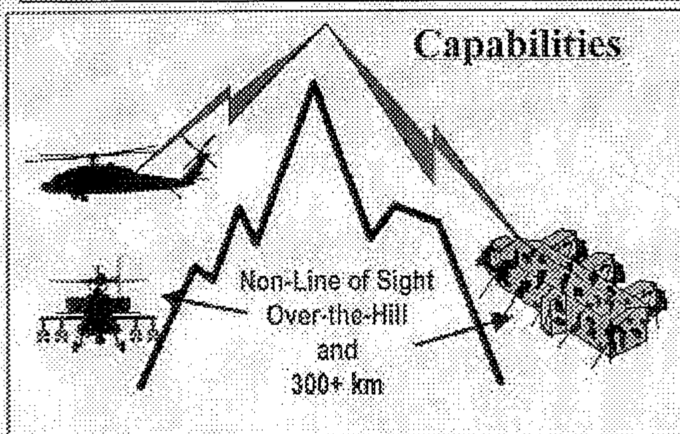
High Frequency Radio
AN/ARC-220



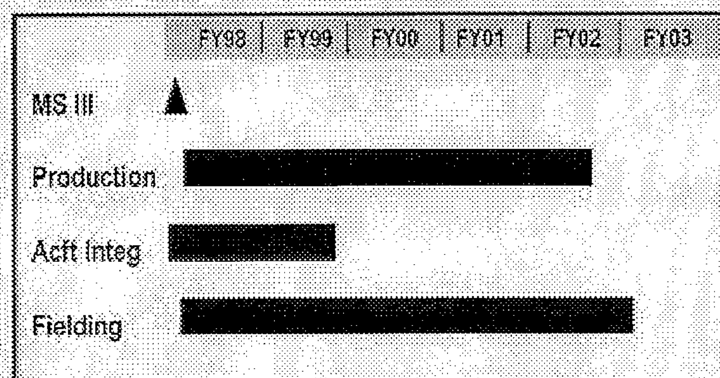
Description

- Long Range Non-Line of Sight Comm for Airborne & Ground Operations
- Form/fit Interchangeable with AN/ARC-199
- Automatic Link Establishment (ALE)

Capabilities

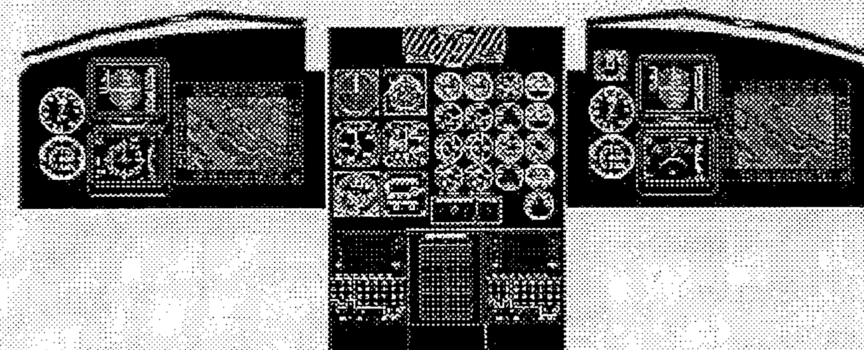


Schedule



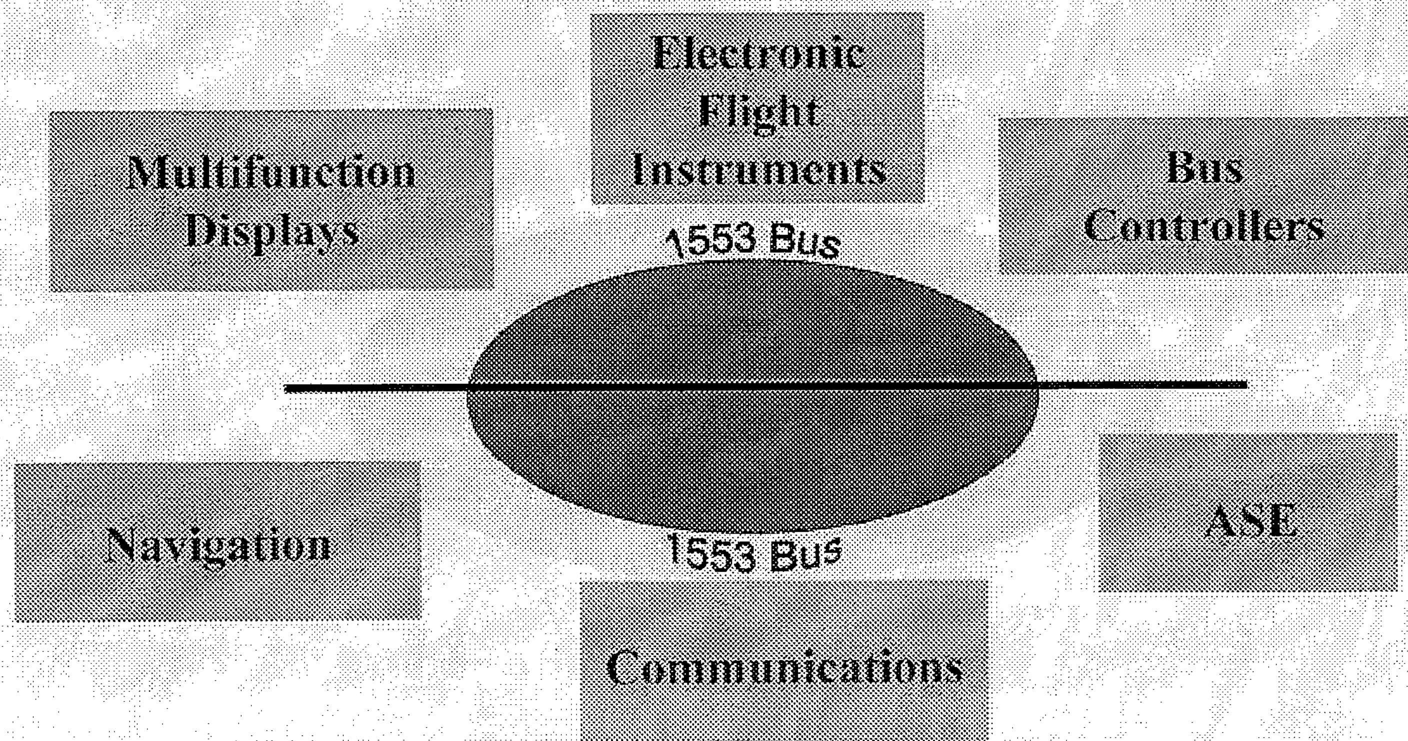
Common Avionics Cockpit

"Notional"



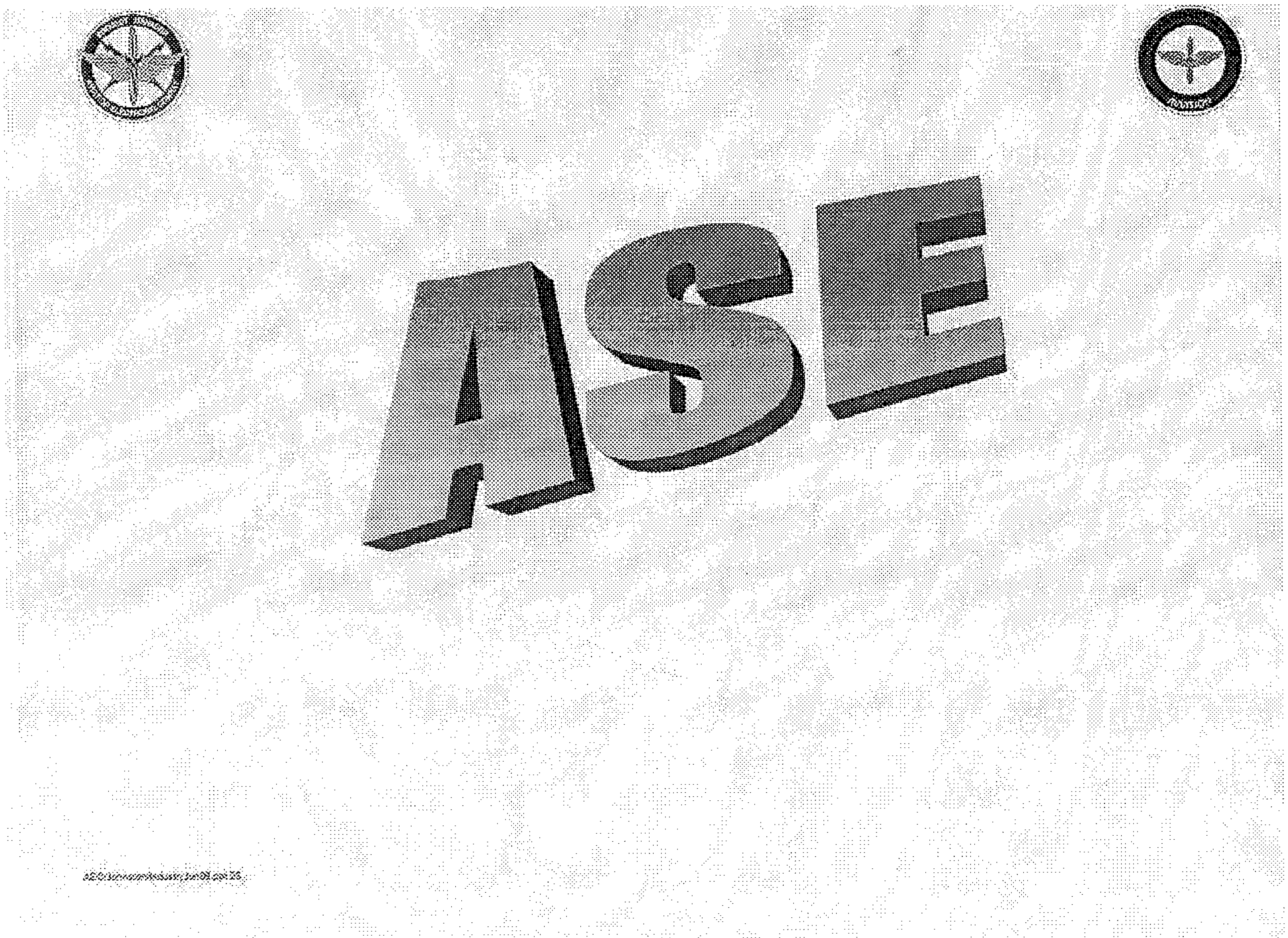
Common	Features
• Hardware	• Modern digital electronics
• Software	• 1553 data bus based
• Functionality	• Integrated cockpit controls and displays
• Supportability	• Reduced pilot workload
• Training	• Integrated communication / navigation
	• Open architecture

Commonality



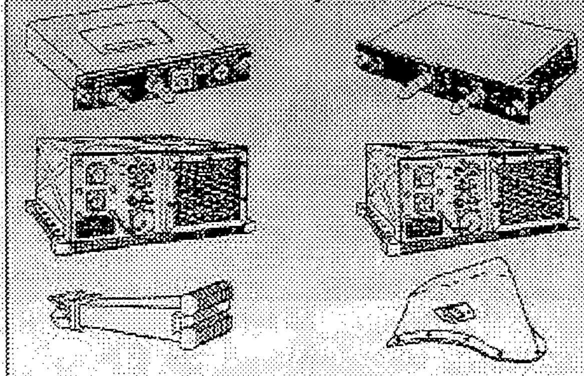
Why Common Avionics Cockpit

- Aircraft Have Common Operational/Functional Requirements
- Affordability- Reduces Life Cycle Cost
  - Reduced logistic support and training cost
  - Provides economic order quantity
  - Allows Common HW/SW Development
- Promotes Common HW/SW Upgrades
- Single Solution for Digitization/Situational Awareness (JTA-A Compliance)
- Heads Aviation Toward Open System Avionics
- Establishes Common Integration Path of Advanced Capabilities (SIIRCM, SIRFC, JCIT, AATI)


ASE

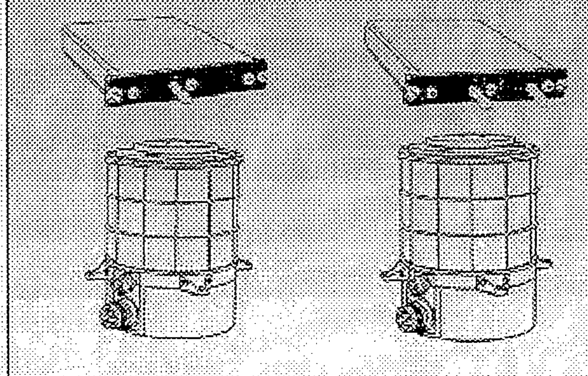
Fielded Aircraft Survivability Equipment

ALQ136



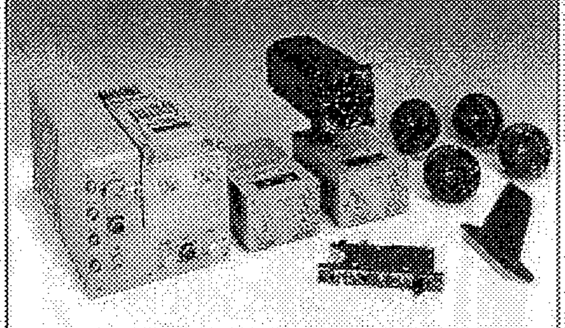
ALQ-136(V)2 ALQ-136(V)1/5

ALQ144

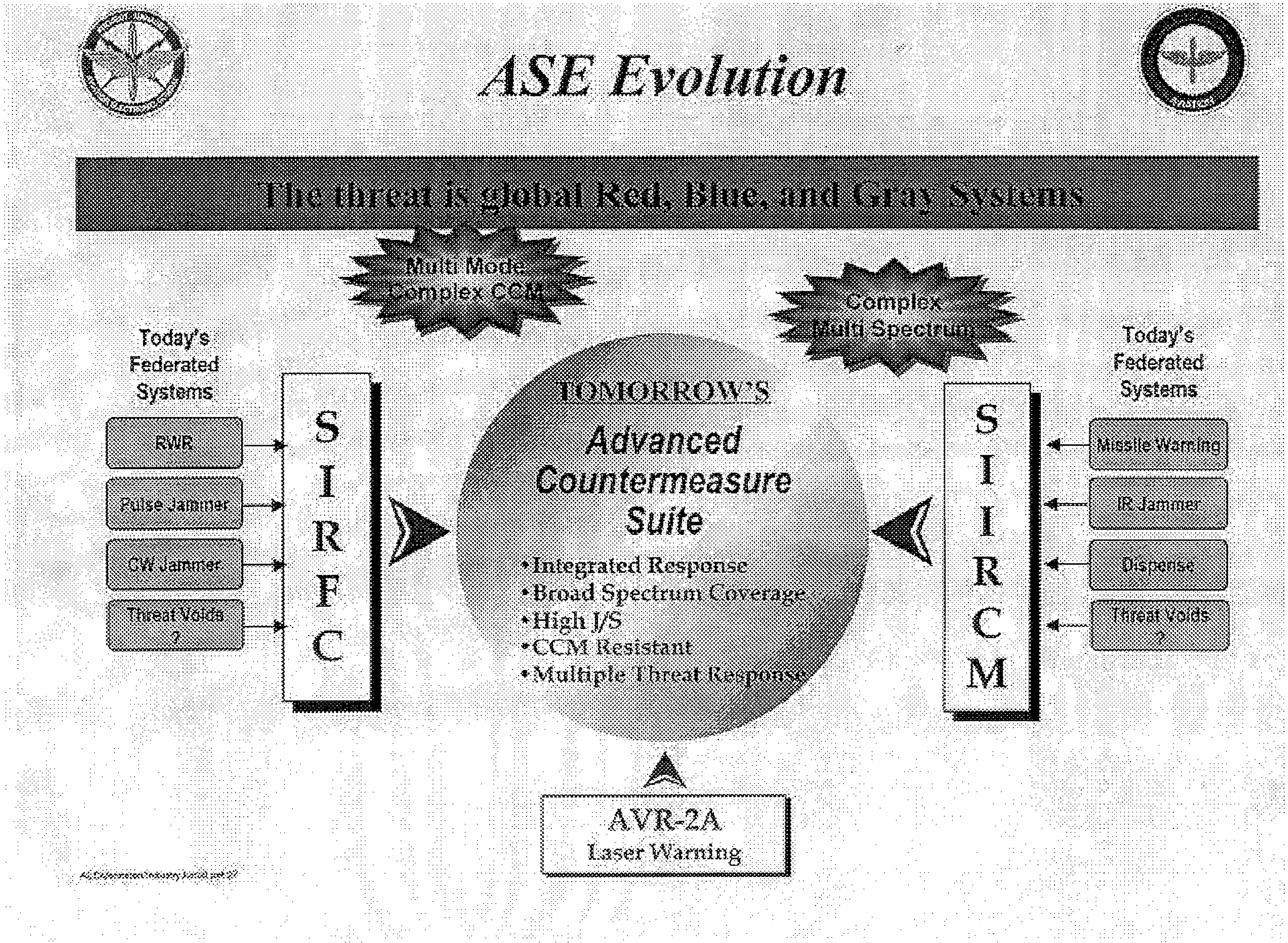


ALQ-144A(V)1 ALQ-144A(V)3

APR39

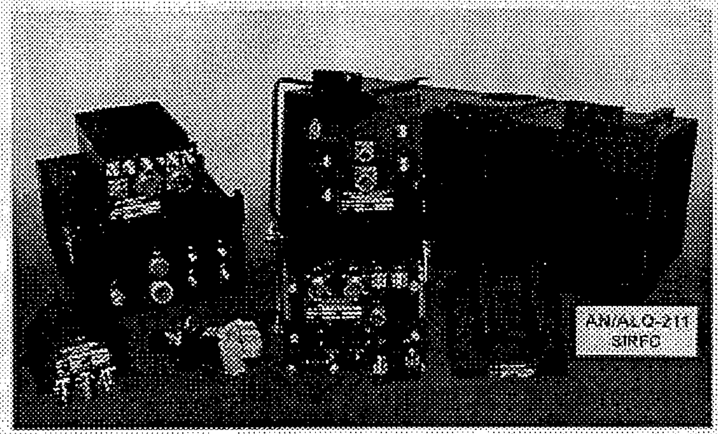


1241


ASE Evolution
The threat is global Red, Blue, and Gray Systems
Multi Mode Complex CCM
Complex Multi Spectrum
Today's Federated Systems
RWR
Pulse Jammer
CW Jammer
Threat Voids ?
S I R F C
TOMORROW'S
Advanced Countermeasure Suite
•Integrated Response
•Broad Spectrum Coverage
•High J/S
•CCM Resistant
•Multiple Threat Response
S I I R C M
Today's Federated Systems
Missile Warning
IR Jammer
Dispense
Threat Voids ?
AVR-2A
Laser Warning

1242

Suite of Integrated RF Countermeasures (SIRFC)



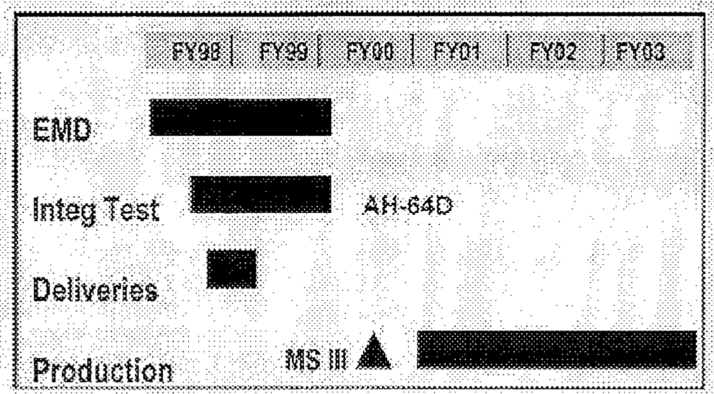
Description

- Integrated RF countermeasures suite
  - RWR and RF ECM
- Replaces current RF ASE
  - APR-39, ALQ-162, ALQ-136
- 4 LRUs - Total weight 97 pounds

Capabilities

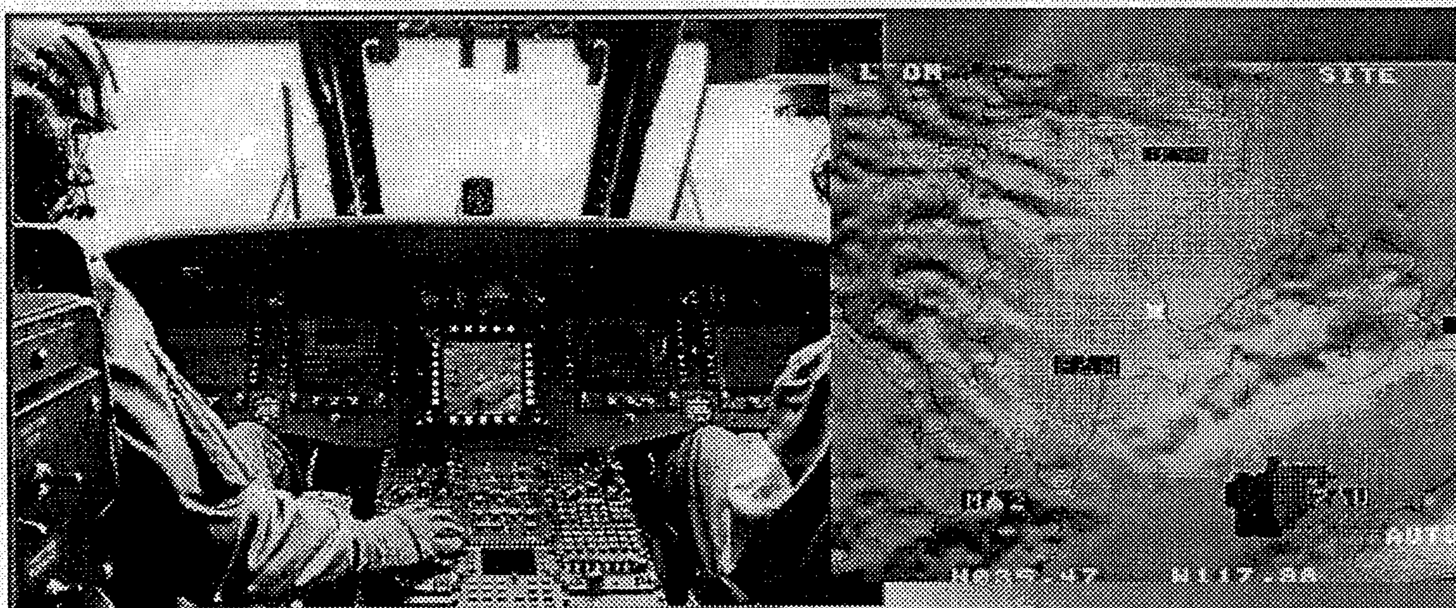
- RF Sensor/Jammer
- Sensor Fusion Processing
- Integrated Response Management
- Broad Spectrum Coverage
- Accurate Threat Location
- Multiple Threat Response

Schedule



1253

Advanced Situational Awareness & Self-Protection



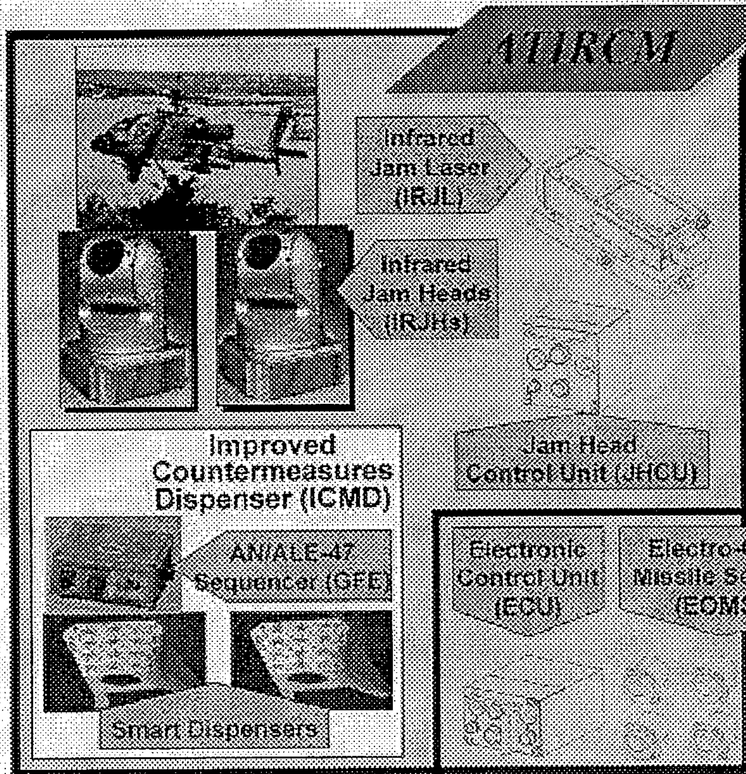
- Displays threat data to aircrews on digital moving map
- Disseminates data to other airborne platforms & ground forces through command and control network

1244

AN/ALQ-212

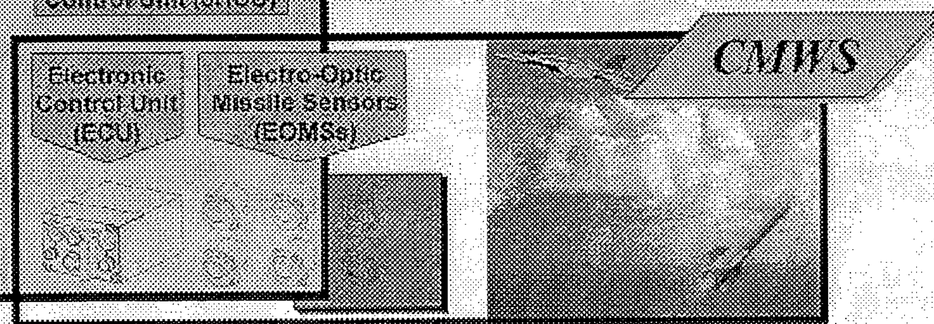
Suite of Integrated IR Countermeasures

ATIRCM / CMWS

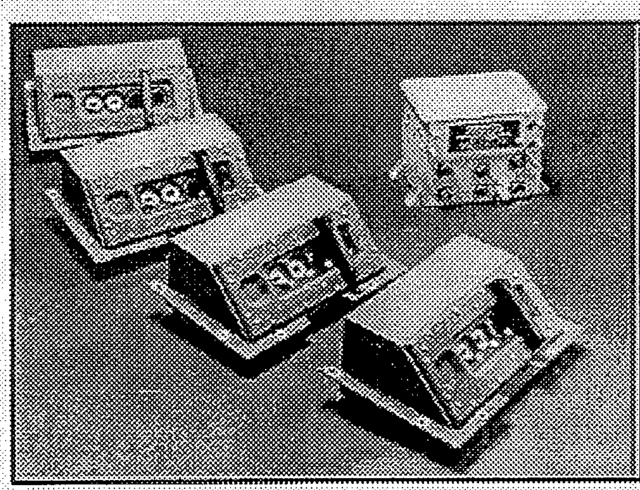


ATIRCM / CMWS U.S. Host Aircraft Platforms		
Army	Air Force	Navy
MH-60K *	F-16	AV-8B *
MH-47E	A-10	F/A-18E/F
MH-60L		
MH-47D		
AH-64D		
EH/UH-60		
CH-47D		
OH-58D		

* Lead service host aircraft platforms



AVR-2A(V) Laser Detecting Set



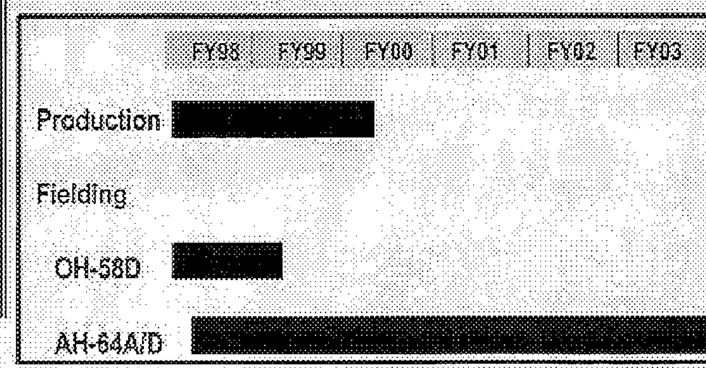
Description

- Provides warning to Aircrew of laser aided weapons via APR-39
- 4 sensors mounted on aircraft surface, 1 interface unit mounted internally
- Wide coverage and high sensitivity

Capabilities

- Detects laser weapons
- Characterizes type of laser
  - Rangefinder, Designator, Beamrider
- Identifies location of threat
- Prioritizes threat according to lethality
- Reports information visually and audibly

Schedule



1247

Aircraft Survivability Equipment Trainer (ASET IV)

Description

- Provides advanced aviation threat training
  - Utilizes tactical mobility and interactive simulation
- 6 HMMWVs
  - 5 - Tactical threat vehicles
  - 1 - C3 vehicle
- Operates with or without instrumentation

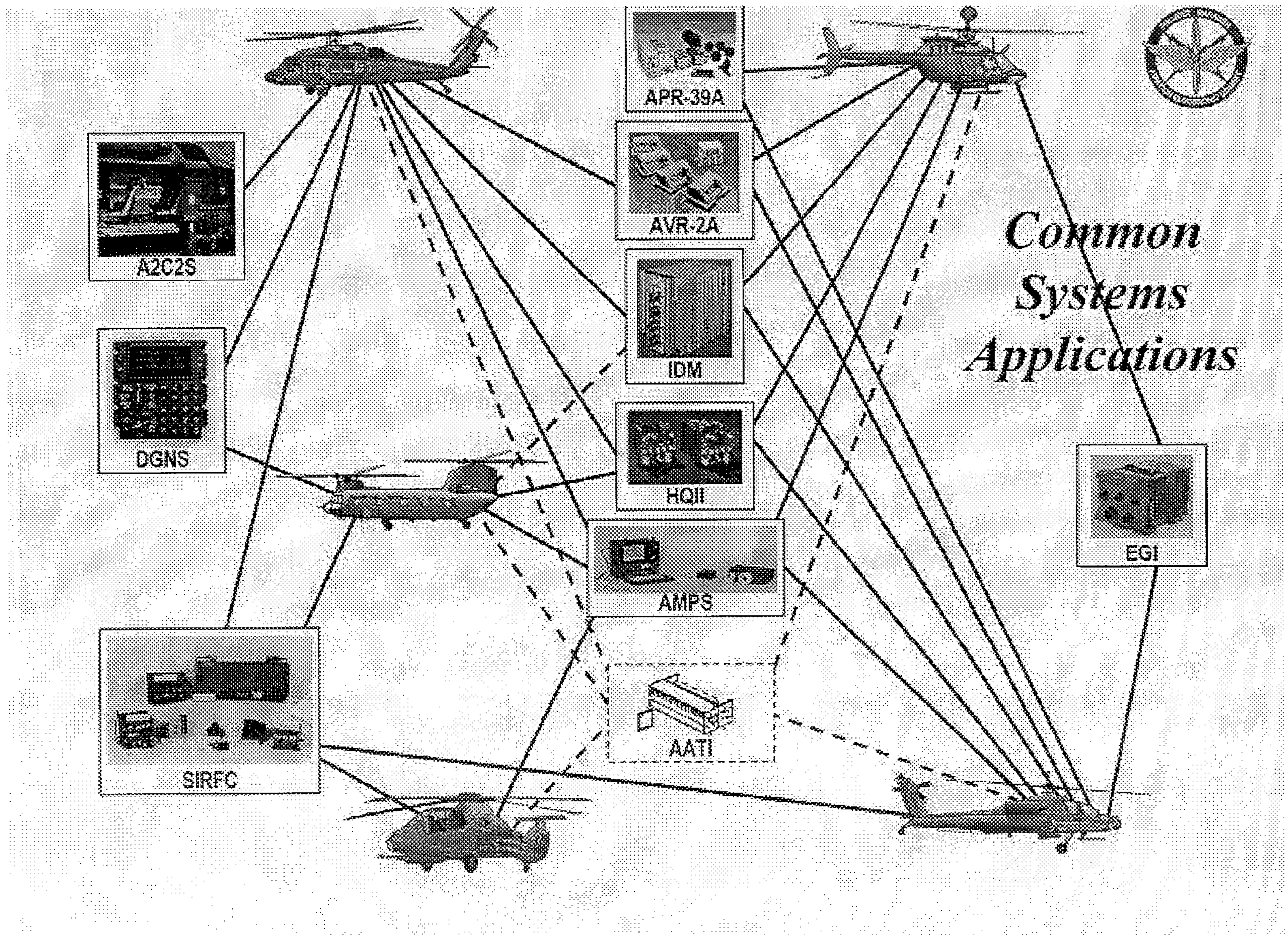
Capabilities

- Air defense threat emitters for force-on-force training
- System improvements
  - Missile threat updates
  - Night vision enhancement for night training

Schedule

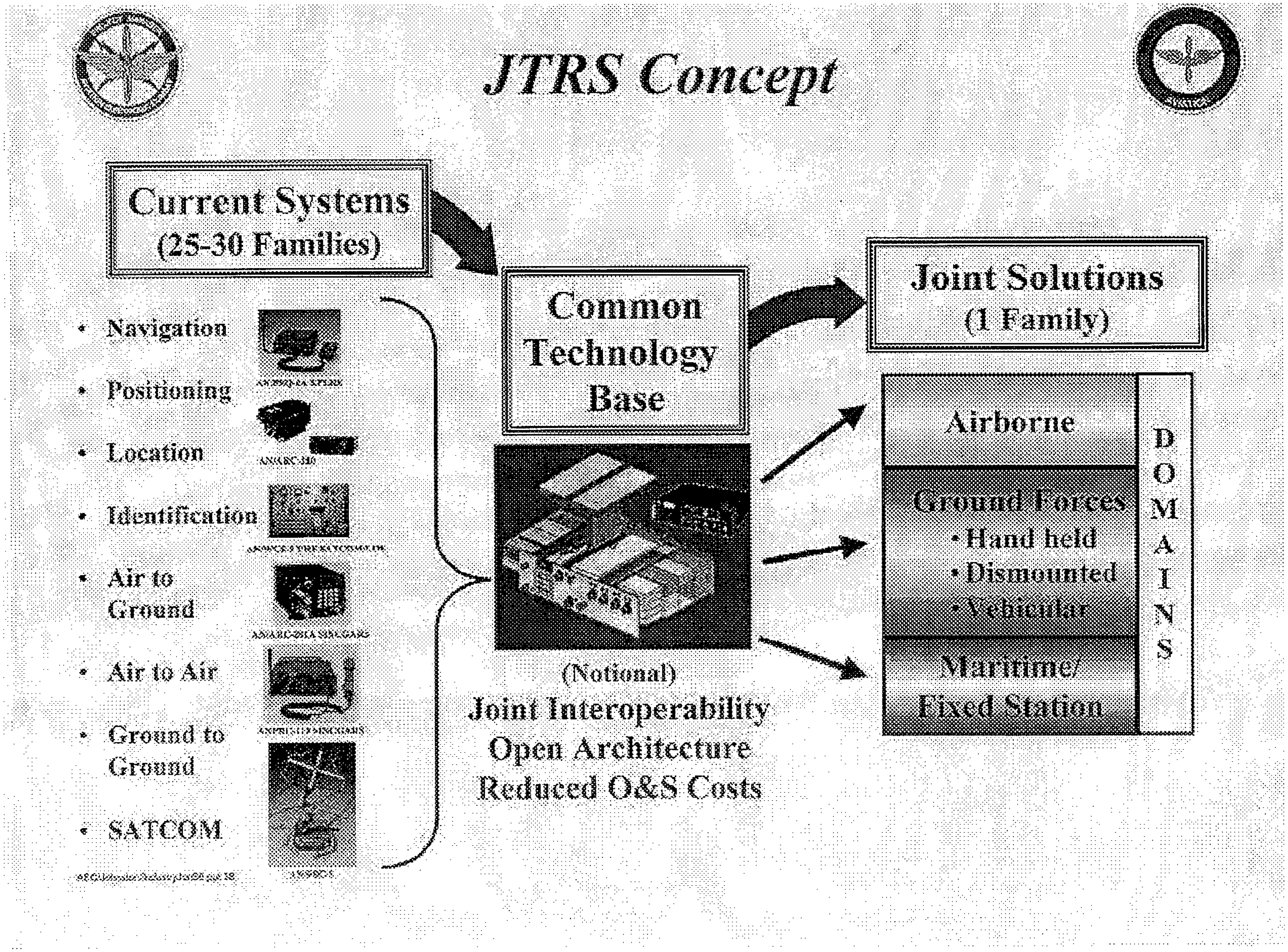
- Production Complete
- Fielded to CTCs (JRTC, CMTC, NTC)
- Field to Home Stations in FY98
  - Ft Hood/Ft Bragg/Ft Campbell

1348


Common
Systems
Applications
APR-39A
AVR-2A
IDM
HQII
AMPS
AATI
A2C2S
DGNS
SIRFC
EGI

1249

Future Avionics


JTRS Concept
Current Systems
(25-30 Families)
• Navigation
• Positioning
• Location
• Identification
• Air to Ground
• Air to Air
• Ground to Ground
• SATCOM
Common Technology Base
(Notional)
Joint Interoperability
Open Architecture
Reduced O&S Costs
Joint Solutions
(1 Family)
Airborne
Ground Forces
• Hand held
• Dismounted
• Vehicular
Maritime/
Fixed Station
DOMAINS

125

Aviation Requirements

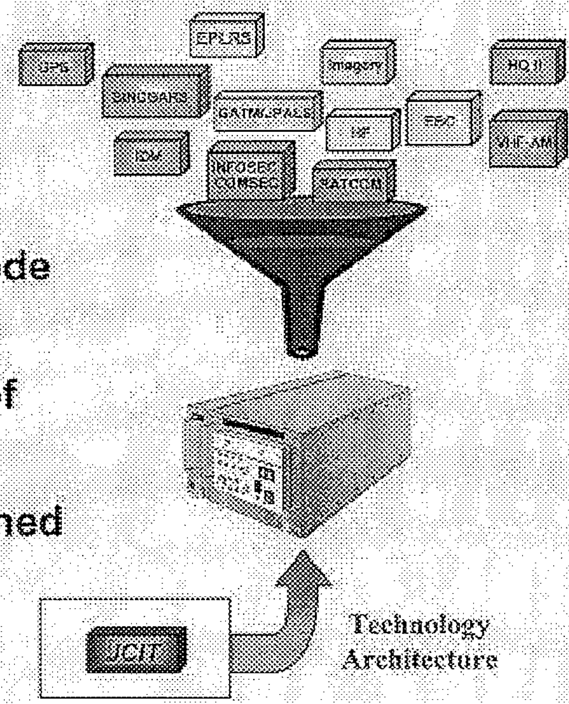
- **Increment One: FY01**
  - Threshold:
    - VHF - FM (SINCGARS ESIP)
    - UHF - AM (HQ II - Joint, Aviation internal C2)
    - VHF - AM (Air Traffic Control)
  - Objective:
    - EPLRS (TI connectivity)
    - UHF DAMA SATCOM (NLOS to TI & Intel)
- **Increment Two: FY02**
  - HF ALE (NLOS connectivity)
- **Increment Three: Beyond FY02**
  - Wideband, etc.

User requirement is to field Increment One in FY01

JCIT as JTRS

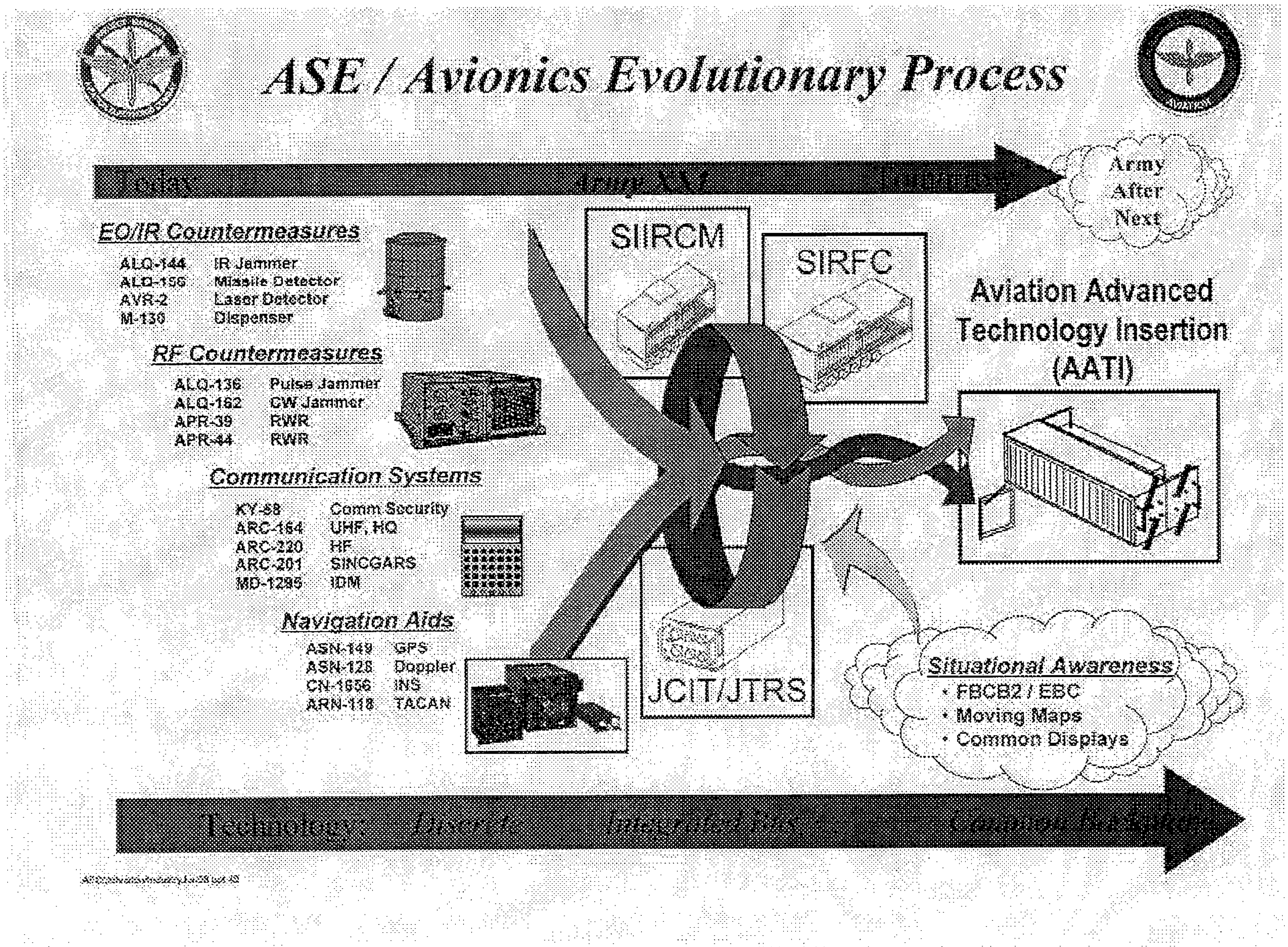
(One Possibility)

- JCIT offers:
  - JTA-A compliance
  - Open system architecture
  - Reprogrammable, multi-band/mode capable
  - Meets all threshold capabilities of Aviation Increment One
  - Operational Test for A2C2S planned for FY99



Army Aviation is lead customer for JTRS

1253

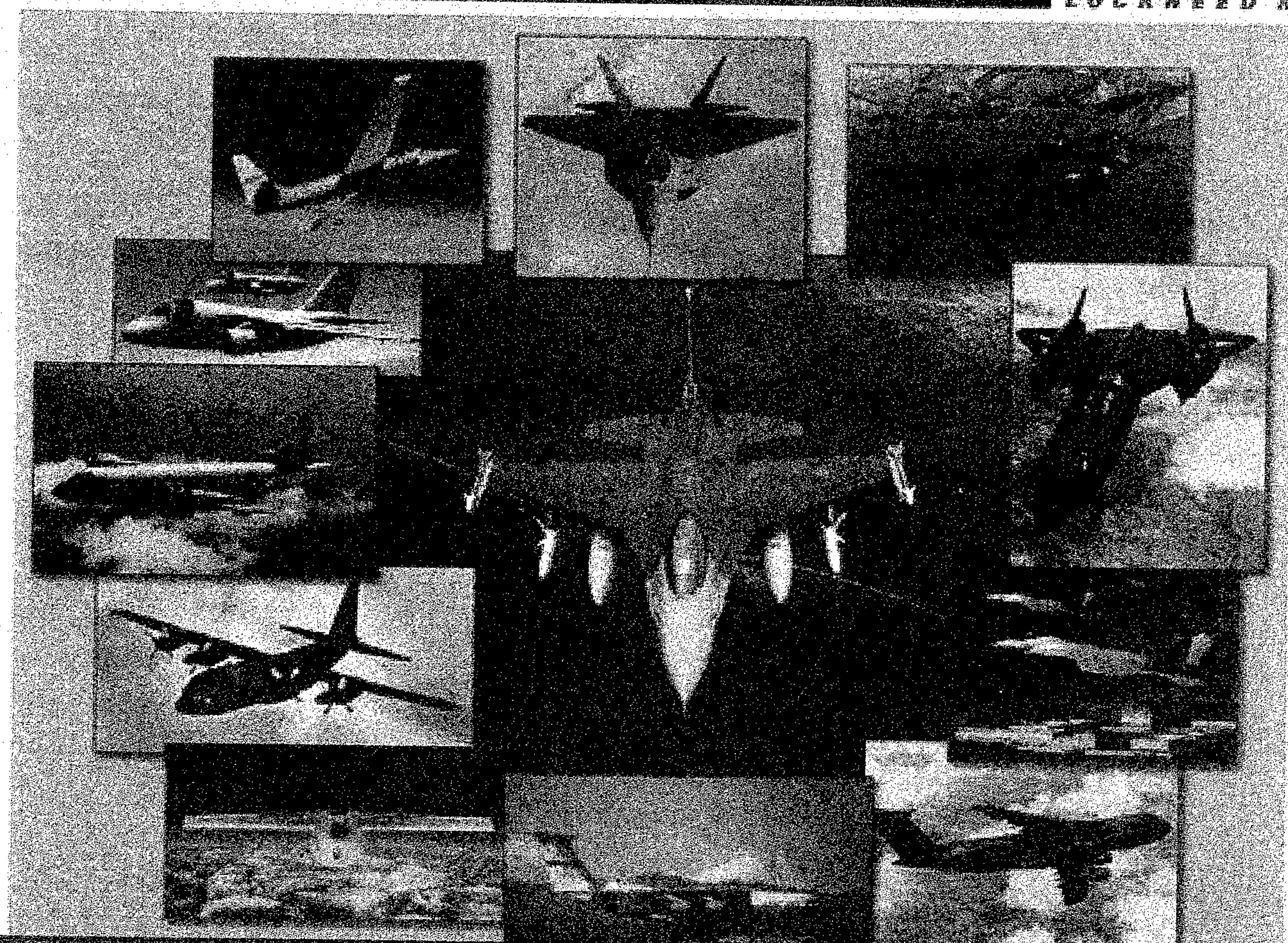

ASE / Avionics Evolutionary Process
Today
Army XXI
Tomorrow
Army After Next
EO/IR Countermeasures
ALQ-144 IR Jammer
ALQ-156 Missile Detector
AVR-2 Laser Detector
M-130 Dispenser
RF Countermeasures
ALQ-136 Pulse Jammer
ALQ-162 CW Jammer
APR-39 RWR
APR-44 RWR
Communication Systems
KY-58 Comm Security
ARC-164 UHF, HQ
ARC-220 HF
ARC-201 SINCGARS
MD-1295 IDM
Navigation Aids
ASN-149 GPS
ASN-128 Doppler
CN-1656 INS
ARN-118 TACAN
SIIRCM
SIRFC
JCIT/JTRS
Aviation Advanced Technology Insertion (AATI)
Situational Awareness
• FBCB2 / EBC
• Moving Maps
• Common Displays
Technology: Discrete Integrated Box Common Backplane

Summary

- *Aggressively developing and producing capable and affordable aviation electronics*
- *Determining direction for future avionics*
- *Significant digitization challenges ahead*
- *Significant opportunity to affect the future*

Lockheed Martin

LOCKHEED MARTIN



Michael Williams
Manager, Systems Integration & SoS
Lockheed Martin Tactical Aircraft Systems

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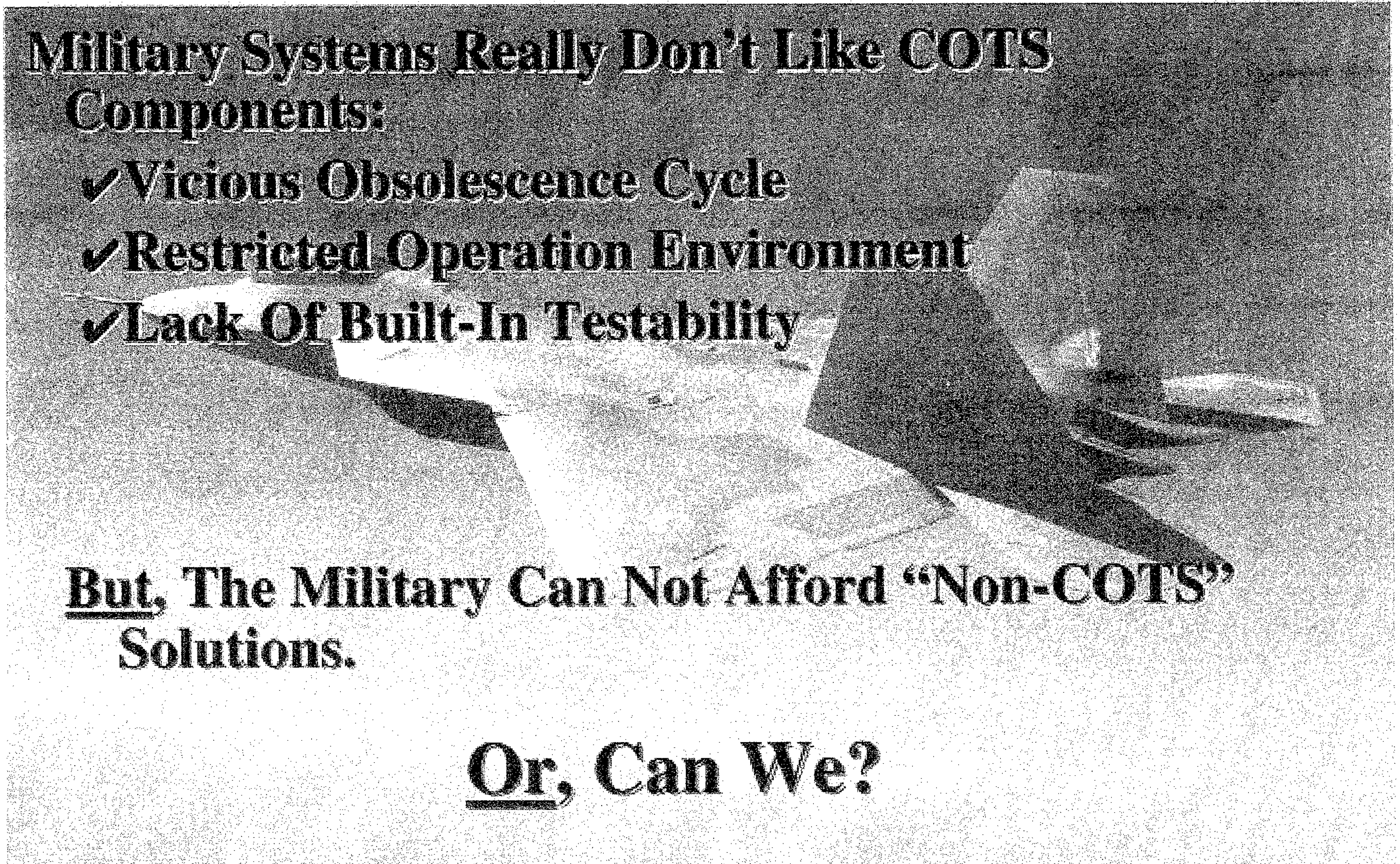
Ideas of Government & Industry Partnerships

LOCKHEED MARTIN

- **Business Practices**
  - Integrated Product Teams*
  - Acquisition Reform & Single Process Initiatives Via Management Councils*
  - Customer Access to Company Databases*
  - Industry Job Fairs for Displaced Government Personnel*
  - Industry Access to Classified Government Databases
  - Collaborative Benchmarking & Independent Program Reviews
- **Technology**
  - Collaborative Technology Planning*
  - Cooperative R&D Agreements (CRADAs)*
  - Prime, Supplier, and Government CRAD IPTs
- **Weapon System Development**
  - Performance Requirements/Specifications
  - Requirements Visualization Tools
  - Collaborative Weapon System Development Environment
  - Government Participation in Supplier Workshops*

* Currently Implemented Within Lockheed Martin

Partnerships Needed to Meet COTS Challenge



Military Systems Really Don't Like COTS Components:

- ✔Vicious Obsolescence Cycle
- ✔Restricted Operation Environment
- ✔Lack Of Built-In Testability

But, The Military Can Not Afford "Non-COTS" Solutions.

Or, Can We?

Modified Military Design/Commercial Off The Shelf Implementation (MMD/COTSI)

LOCKHEED MARTIN

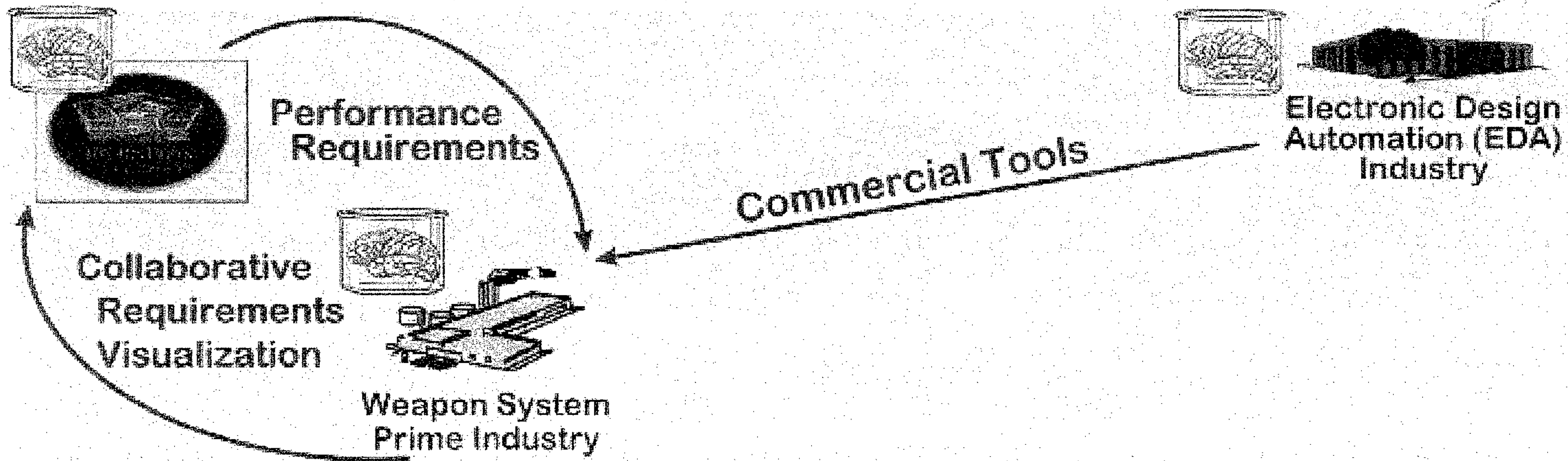
<u>Problem</u>: A Parts-Based Solution (Any Parts) Ignites an Obsolescence Time Bomb.

<u>Solution</u>: Modify Military Design Processes And Use Commercial Just-In-Time (JIT) Manufacturing.

- ✔ Create Military Designs Which Are Independent of Component Implementation Technology.
- ✔ Stockpile Design, Not Parts.
- ✔ Manufacture In "Then-Year" Technology Using Commercial Foundries (RASSP Example).
- ✔ Leverage Commercial Tools and Processes.
- ✔ Repair and/or Upgrade in "Then Year" Technology With JIT Parts.

20,000 Foot View of The MMD/COTSI Process

LOCKHEED MARTIN



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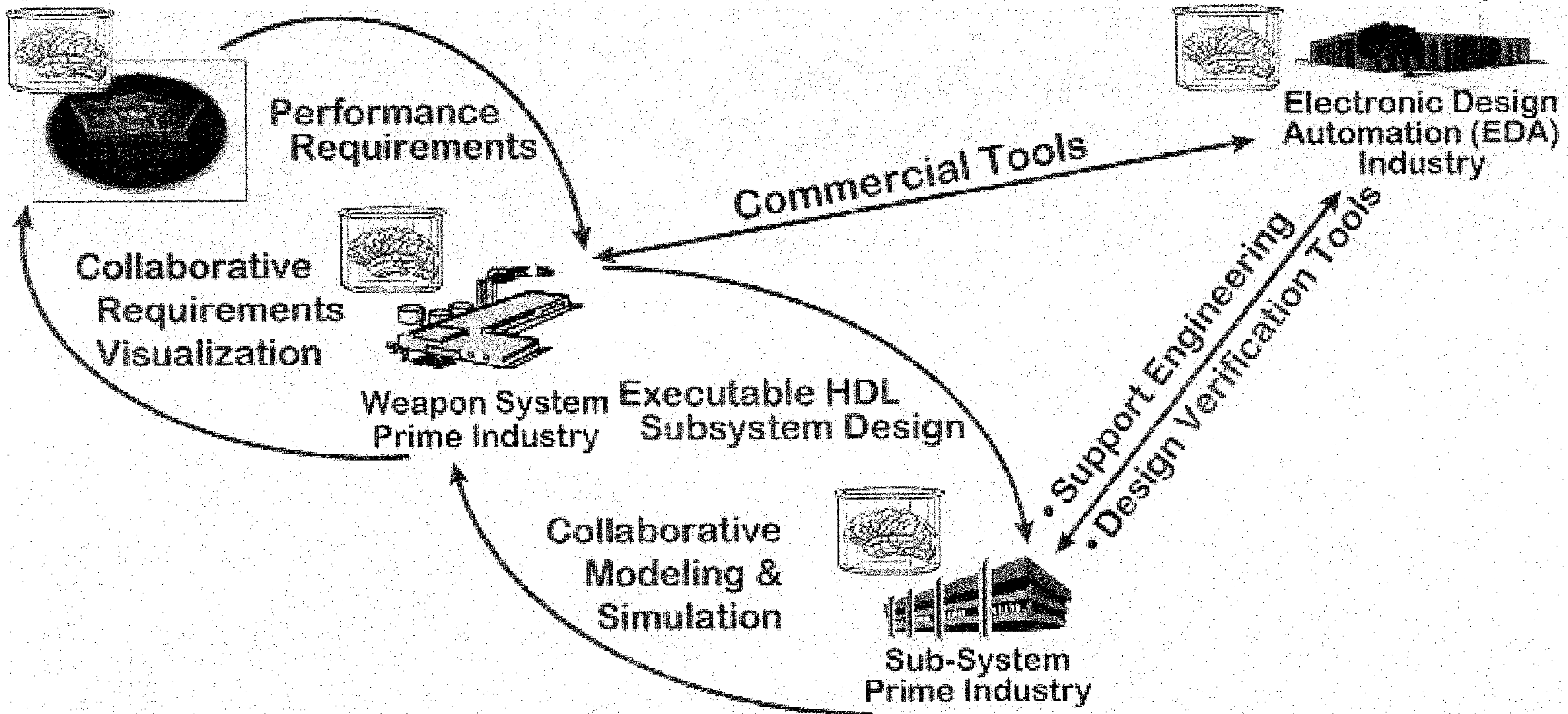
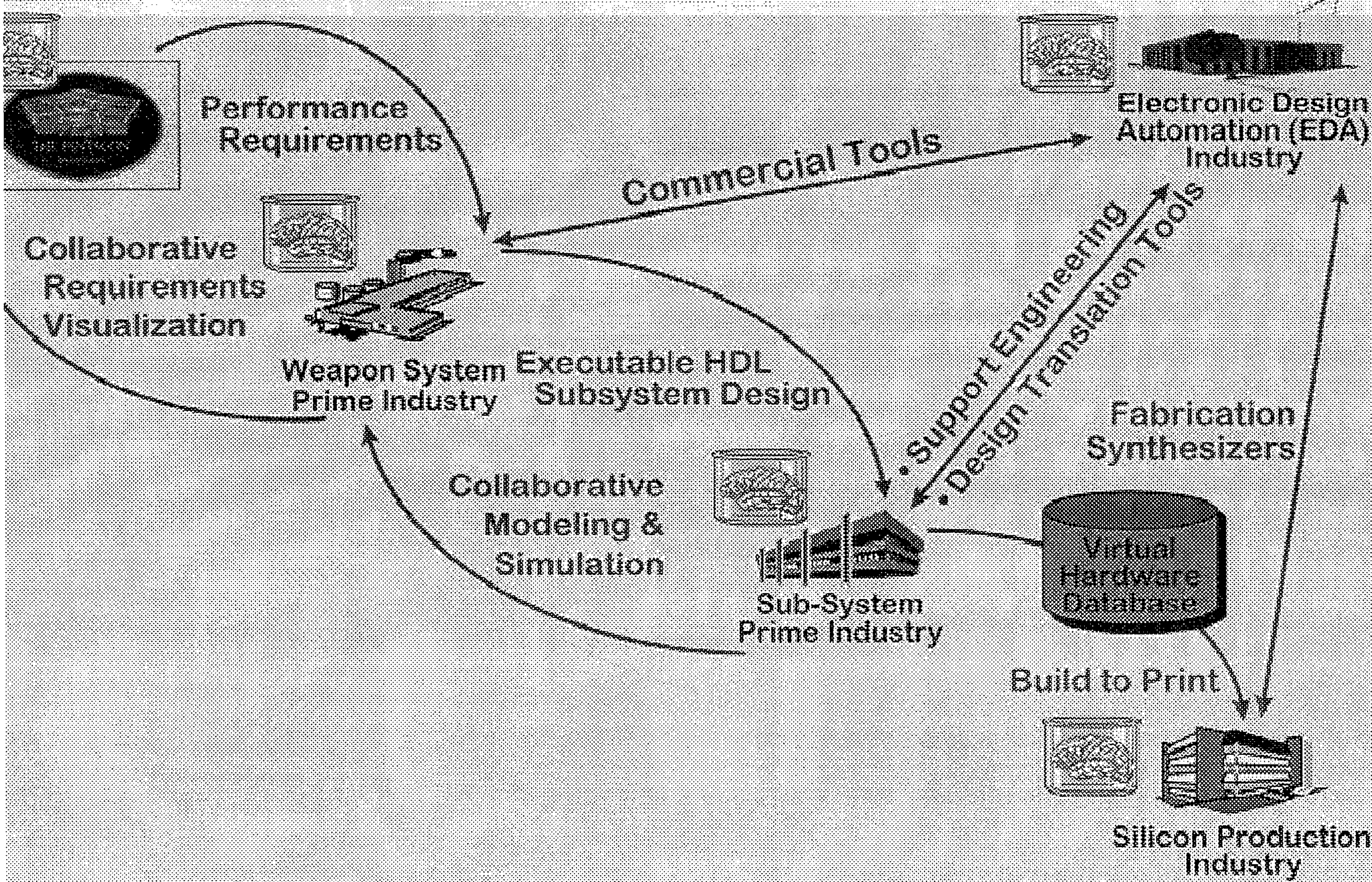
20,000 Foot View of The MMD/COTSI Process

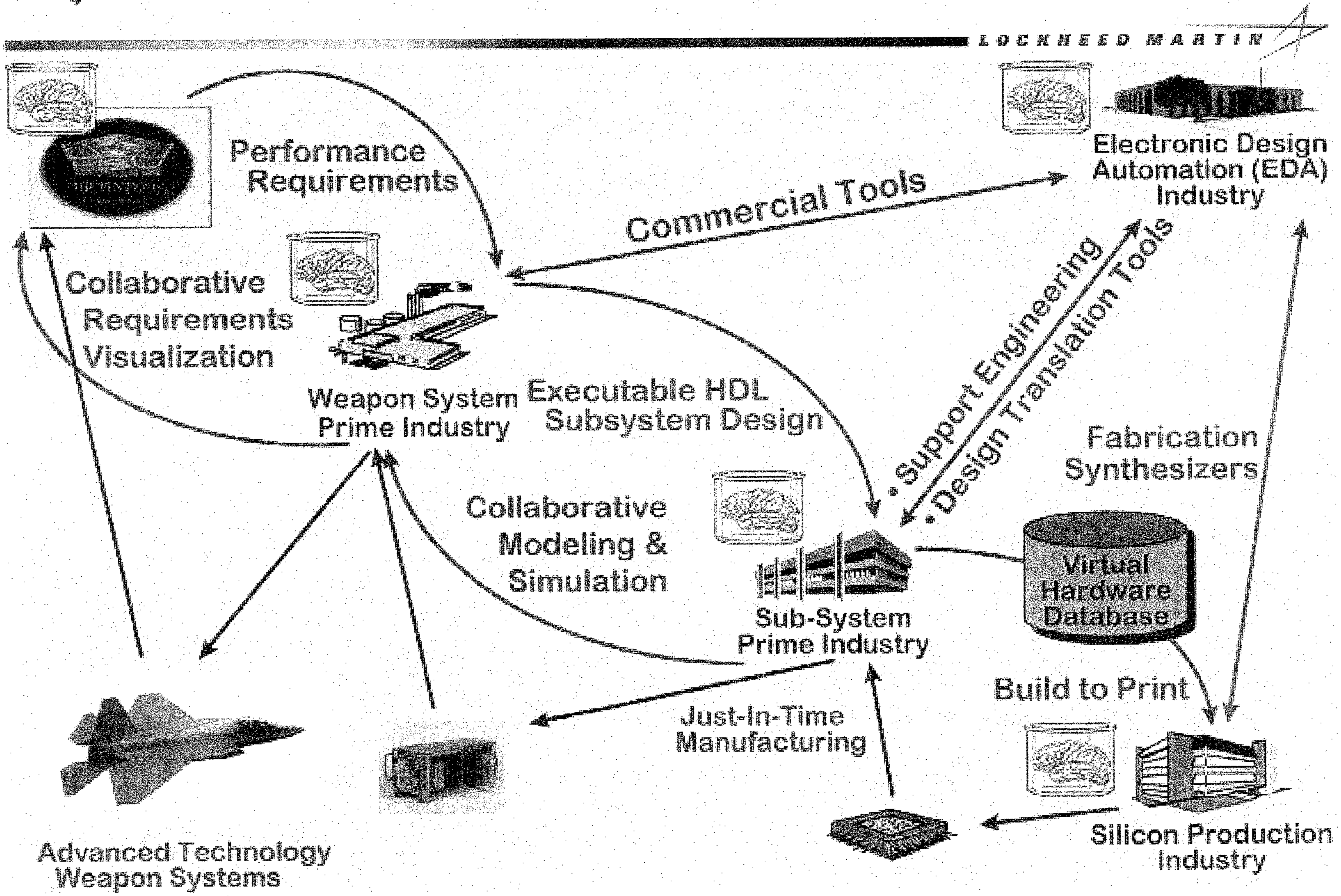
LOCKHEED MARTIN



0,000 Foot View of The MMD/COTSI Process



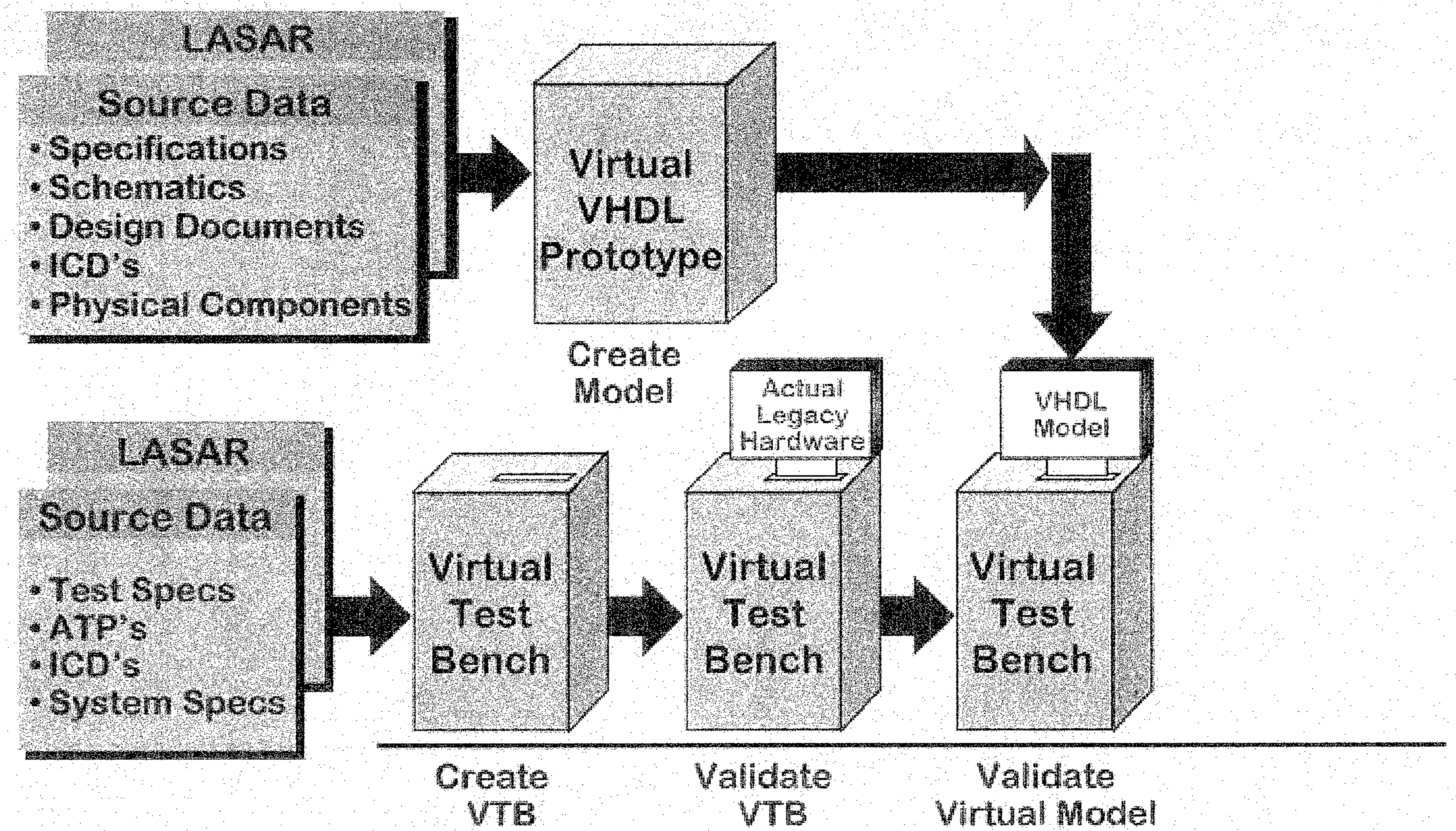
20,000 Foot View of The MMD/COTSI Process



A View of Our Legacy MMD/COTSI Process

LOCKHEED MARTIN

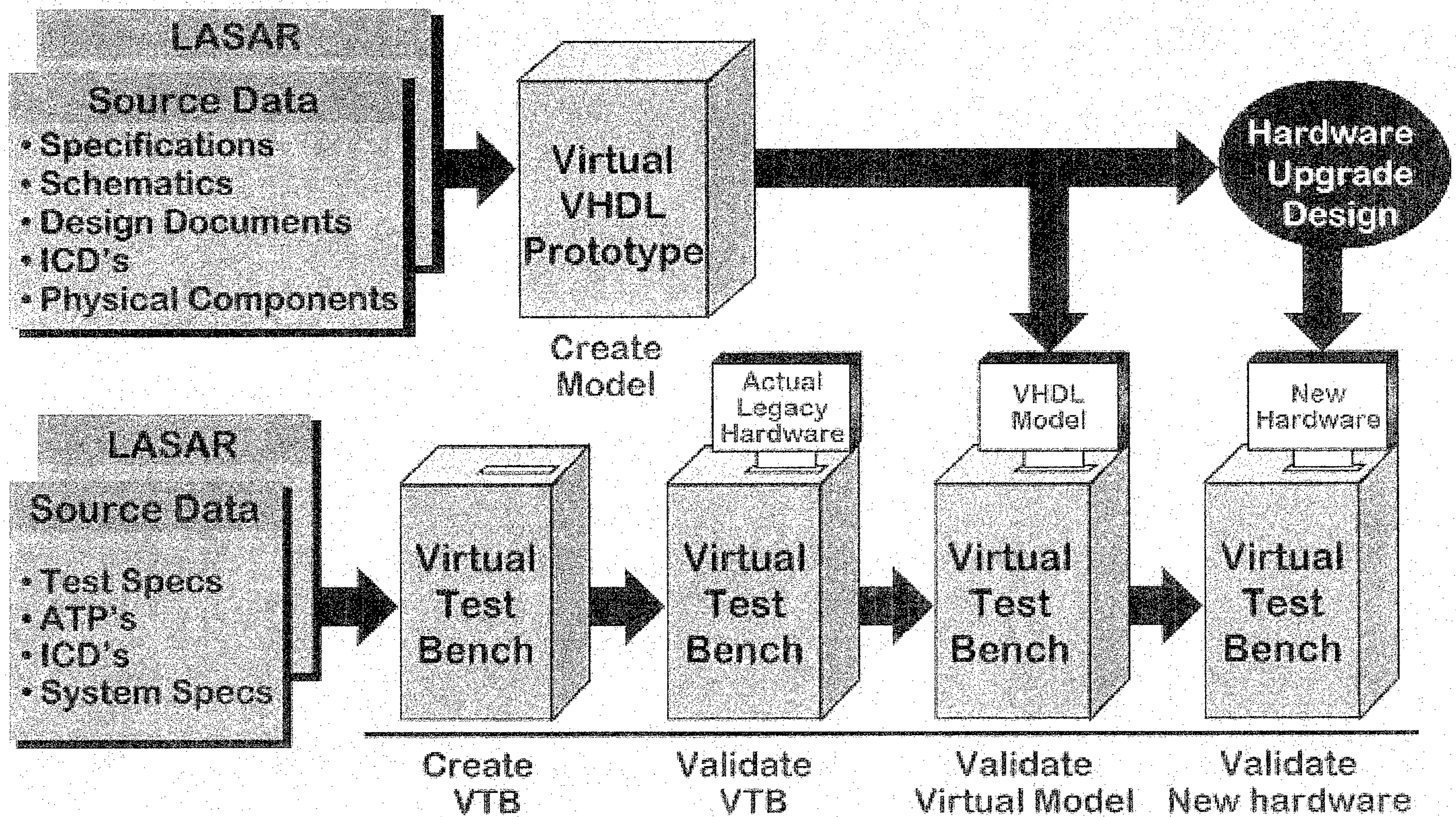
VHDL Model and Test Bench Validation Environment



A View of Our Legacy MMD/COTSI Process

LOCKHEED MARTIN

VHDL Model and Test Bench Validation Environment



Summary

The Military Can Use COTS (MMD/COTSI) IF...

- ✔ We Segregate Our Designs From Implementation Technology Obsolescence
- ✔ We Use Commercial Practices, Processes, and Toolsets To Capture Our Designs
- ✔ Our Military Design Provides For Component Testability
- ✔ We Adopt Commercial Practices Such as JIT and Lean Manufacturing
- ✔ We Figure Out How To Do Affordable System Qualification...

This is Not Possible Without Close Partnerships Between Government and Industry

AIR FORCE MATERIEL COMMAND

AIR FORCE FLIGHT TEST CENTER

AFEWES

Air Force Electronic Warfare Evaluation Simulator

Air Force Plant No. 4 - Fort Worth, Texas

AFEWES Mission

Provide Technical Evaluations of the Performance of EC Systems and Techniques in simulated IR/UV/RF environments.

CAPABILITIES

- RF Countermeasure Evaluation:
  - RF SAMs
  - RF AAMs
  - Airborne Interceptors
- IR Countermeasure Evaluation:
  - IR SAMs
  - IR AAMs
- IR/UV/RF MWS Evaluation

RF SIMULATIONS

- RF OPEN-LOOP SIMULATION
  - Evaluate EC Receivers & Sensors
  - One-way path
  - Dense RF Signal Environment
- RF CLOSED-LOOP SIMULATION
  - 1-v-1 Technique Development & Optimization
  - Two-way Path for Jammer Effectiveness Tests
  - Chaff, Maneuver & Dense RF Environment

RF OPEN-LOOP SIMULATOR

- High-Fidelity RF Environment for Testing RWR & Power Managed Jammer
- Capability of up to 217 Emitters
- Configure to Specific Threats and Operating Area, Includes Terrain Masking
- Stand-Alone or with Closed-Loop Simulator

CLOSED-LOOP SIMULATIONS

SA-2	SPIN SCAN	SA-7A,B	GUN DISH
SA-3	JAY BIRD	SA-9	FLAP WHEEL
SA-4	FOX FIRE	SA-13	LONG TRACK
SA-5M	FLANKER	SA-14	WILD CARD
SA-6M	FULCRUM	SA-16	TACAN
SA-8	FOXHOUND	SA-18	IFF
	REDEYE	STINGER	C3 (4,8)

NEAR TERM IMPROVEMENTS & MODERNIZATION

RF CLUTTER	**1QFY99**
SA-10	**4QFY98**
IR SAM	**1QFY99**

UNIQUE ADVANCES IN HARDWARE-IN-THE-LOOP

IR AA-11	4QFY98
JMASS-6	1QFY99
UV/IR MWS	2QFY99
SA-12	4QFY99

AFEWES LINKING

Evaluate the utility of using electronically linked test assets for EW technical evaluations.

LINKING OVERVIEW

- MILESTONTES (1985 - 1997)
- LINKING 1998
- LINKING 1999
- SUMMARY

LINKING MILESTONES

1985 AFEWES & FLIGHT SIM LAB (FSL)

1988 AFEWES/FSL AIR WARFARE CENTER TACTICS DEVELOPMENT

1991 AFEWES/REDCAP/EMTE DEMONSTRATION

1995 AFEWES/FSL DATA LATENCY

1996 T&E ENGINEERING PROTOFEDERATION

1997 THREAT SIMULATION LINKING ACTIVITY

LINKING 1998

JOINT ADVANCED DISTRIBUTED SIMULATION ELECTRONIC WARFARE (JADS-EW)

- **PURPOSE:** DETERMINE UTILITY FOR D/OT&E
- **SCOPE:** BASELINE AT OAR
  REPLICATE OAR IN JADS ENVIRONMENT
- **OBJECTIVES:** MEASURE PERFORMANCE
  ESTABLISH VARIABILITY
  CORRELATE RESULTS
  QUANTIFY EFFECTS

LINKING 1998

JOINT ADVANCED DISTRIBUTED SIMULATION ELECTRONIC WARFARE (JADS-EW)

- PHASE I: OAR BASELINE (AFEWES, OAR, JTF) 4/98
- PHASE II: DSM (AFEWES, ACETEF, JTF) 10/98
- PHASE III: (AFEWES, ACETEF, JTF) 5/99

LINKING 1999

AFFTC AND NAWC
LINKED MULTI-FACILITY
ELECTRONIC WARFARE EXERCISE

- OSD FOUNDATION INITIATIVE
- AFOTEC IS TEST SPONSOR
- PURPOSE: CONDUCT REAL-TIME MISSION LEVEL UAV TEST WITH HLA LINKS TO USAF & USN GROUND & OAR TEST ASSETS

LINKING SUMMARY

- 6 MILESTONES (1985 - 1997)
- LINKING 1998 (JADS-EW)
- LINKING 1999 (AFFTC/NAWC)

SUMMARY

- AFEWES provides a high density signal environment, in a secure facility, for testing ECM systems and techniques.
- DT&E/OT&E in IR/UV/RF environments.
- Air-to-air and surface-to-air threat simulations.
- Local and distributed scenarios (HLA)

EDWARDS AFB AVIONICS TEST AND INTEGRATION COMPLEX

LT COL RANDY KELLY, USAF
CHIEF
412 TW/EWW
850-277-3404
kellyrk%ewwl@mhs.elgn.af.mil

PURPOSE

- PROVIDE AN OVERVIEW AND UPDATE OF THE GROUND TEST FACILITIES AT EDWARDS AFB's AVIONICS TEST & INTEGRATION COMPLEX

OVERVIEW

- **BACKGROUND:** How has the environment changed?
- **GROUND TEST FACILITIES AT THE ATIC:** A quick overview.
- **THE FUTURE GROUND TEST ENVIRONMENT:** "Virtual Boy"* in the attic?

intro

* Registered trademark of Nintendo 2

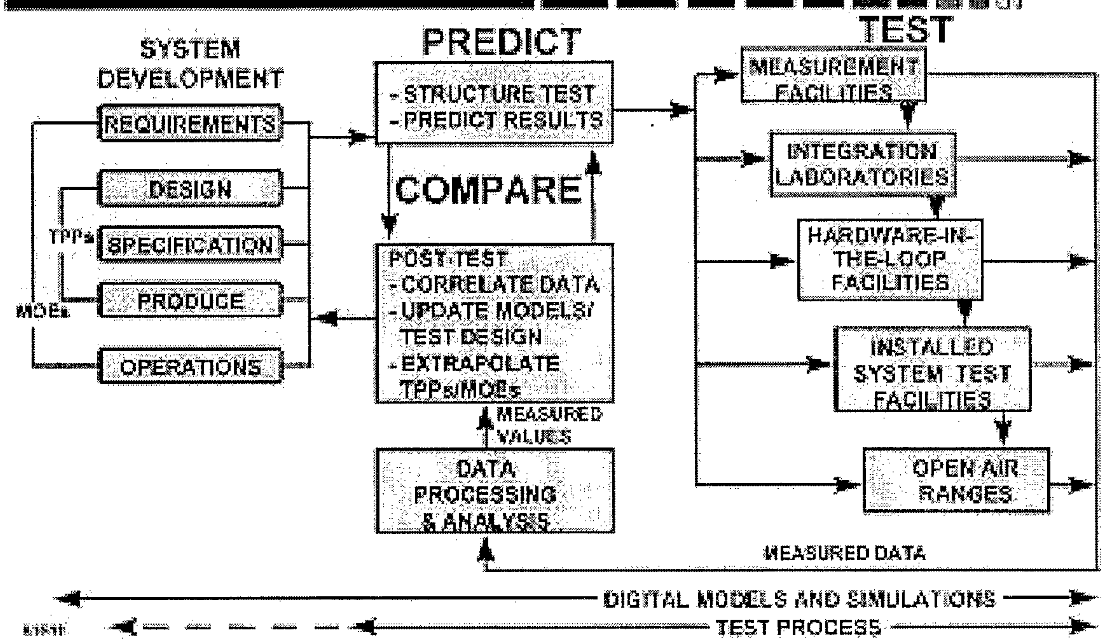
BACKGROUND

- Evolutionary, and revolutionary aircraft changes
  - From performance &flying qualities is ONLY problem, to -
  - Integrated avionics is BIGGEST problem
- EW systems experienced similar change
  - From, observer in "lighter than air" craft, to -
  - Complex "do it all" EW systems
    - Detect, identify, and provide situational awareness
    - Determine appropriate actions
    - Initiate countermeasures & cue maneuvers

BACKGROUND
THE "TEST PROCESS"

- The standard "Fly - Fix - Fly" cycle
  - Simple; plan, fly, fix, fly, fix, fly, ...fly$$
- The recursive but disciplined "Predict - Test - Compare" cycle
  - Predict using models & simulation tools
  - Test using appropriate facility
  - Compare to predictions
  - Feedback results to mitigate risk and improve models (plus lower regression test rqmts)

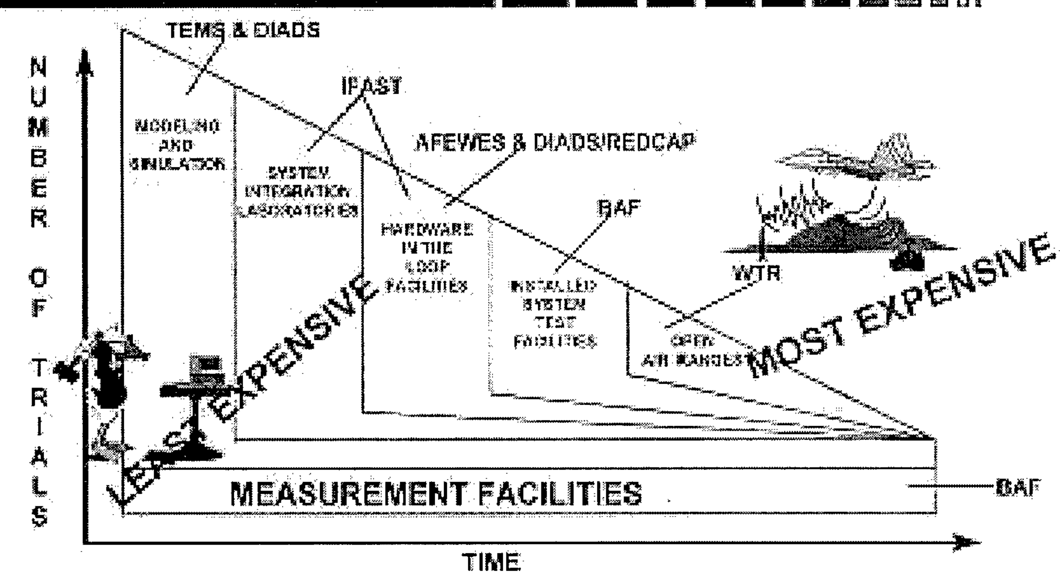
AVIONICS & EW
T&E PROCESS



IMPORTANT REMINDERS

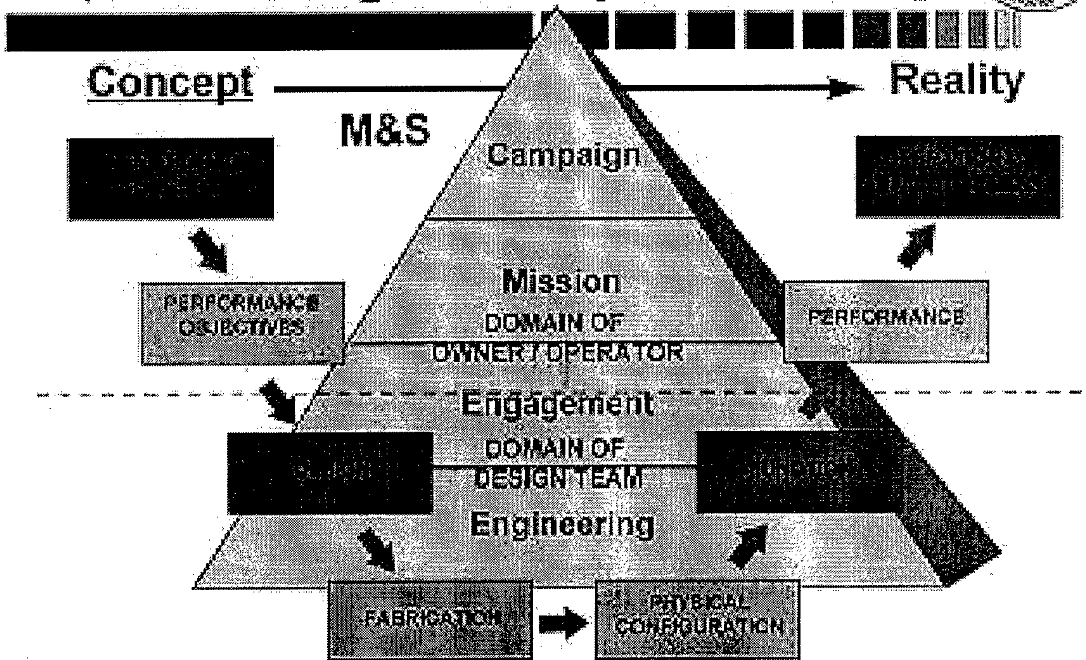
- M&S and ground test facilities are not replacements for flight test
- Generally, no single facility can provide the entire answer
- Facility decisions depend on risk management strategy, program phase, $$$, and time
- Strong synergy in co-located facilities

AFFTC FACILITY HIERARCHY

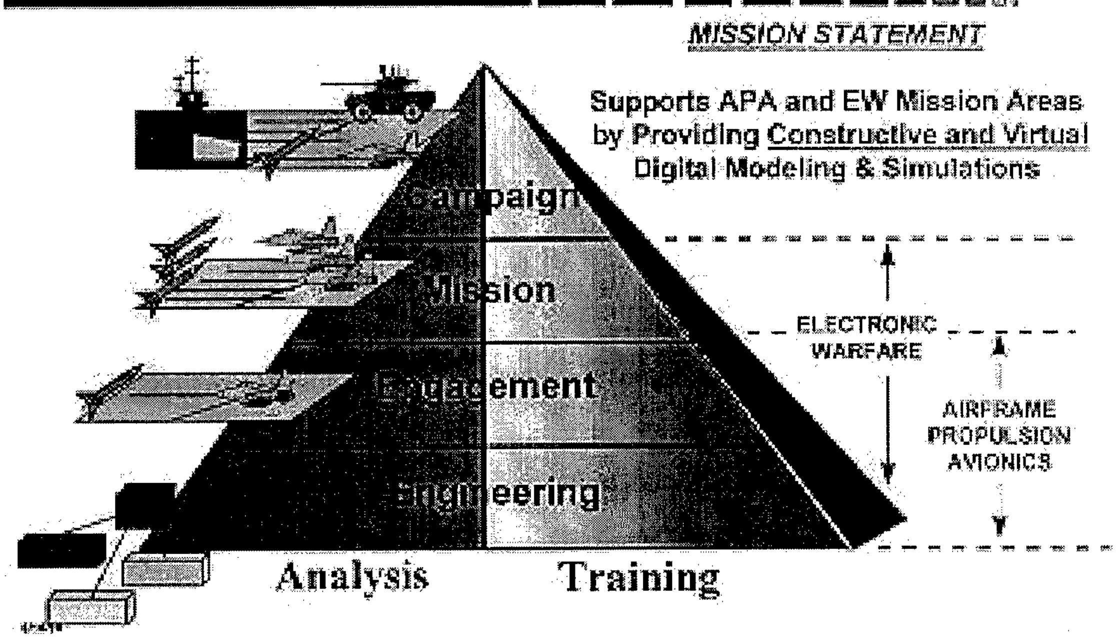


RELATIVE USE OF T&E RESOURCE CATEGORIES

M&S
Linking Concept to Reality



CAPABILITIES
TEMS



CAPABILITIES

TEMS

CONSTRUCTIVE SIMULATIONS

Campaign

- THUNDER
  - Multi-Day Campaign; Theater Level
  - Force-on-Force; Air-Land Battle

- SUPPRESSOR
  - Air Superiority/SEAD; Mission Level
  - Many-vs-Many; Air-Land Battle

Mission

- DIADS
  - Enemy IADS; Mission Level
  - Many-vs-Many; Air-Land-Battle

Engagement

- ESAMS
  - Survivability; Engagement Level
  - One-vs-One; Air-Land Battle

- JMASS
  - Simulation Architecture
  - Engineering and Engagement

Engagement
Engineering

CAPABILITIES

TEMS

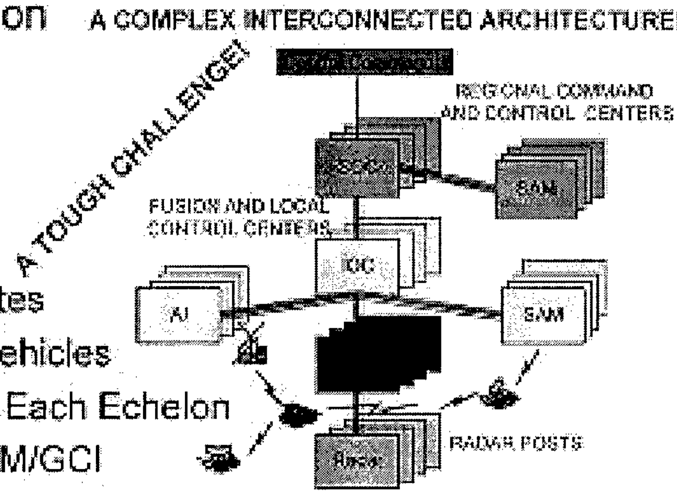
VIRTUAL SIMULATIONS, MODELS, & COCKPITS

- AERODYNAMIC
- ENGINE
- EQUATIONS OF MOTION
- TARGETS
- THREATS
- INTEGRATED AIR DEFENSE SYSTEMS
- FLIGHT CONTROL SYSTEMS
- AIRCRAFT SYSTEMS
- ATMOSPHERIC
- AVIONICS COCKPIT DISPLAYS
- ELECTRONIC WARFARE DISPLAYS
- MISSILE FLY-OUTS
- B-1B, F-16, F-22, TES generic cockpit

MODELING THE IADS

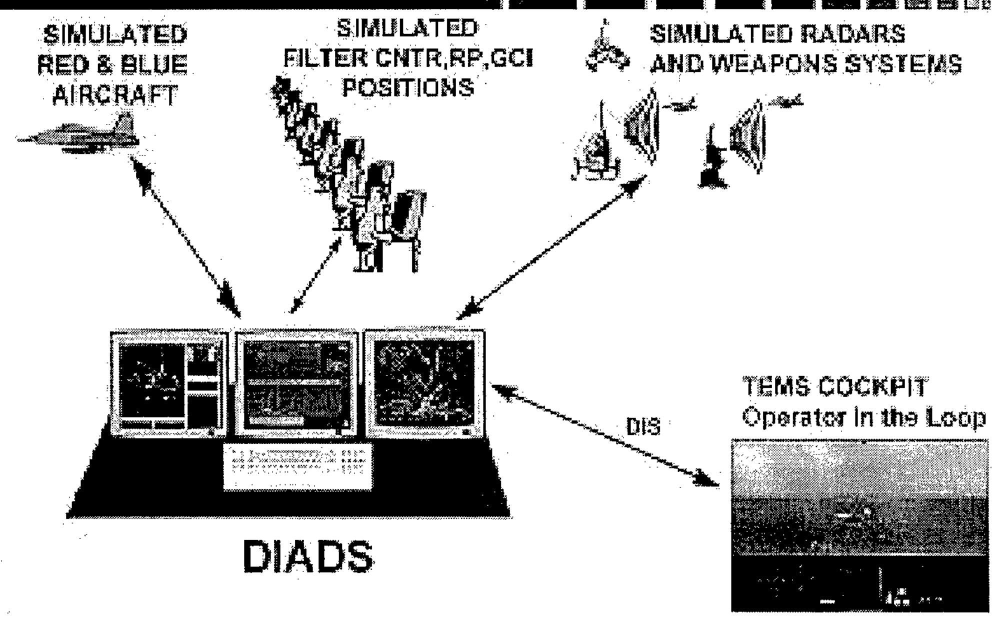
- Scenario Preparation
  - Build Laydown
  - C2 Rules
  - Prepare Mission
- Mission Execution
  - Ready Selected Sites
  - Initiate Attacking Vehicles
  - View Air Picture at Each Echelon
  - Assign Targets SAM/GCI
  - Conduct Engagement

A COMPLEX INTERCONNECTED ARCHITECTURE!



DIADS

- Digital Integrated Air Defense System-



CAPABILITIES
TEMS - STANDALONE DIADS

- Air Defense Ops Center (ADOC)
- 4 Sector Ops Centers (SOC)
- 15 Integrated Ops Centers (IOC)
- 20 AAA Command Centers
- 75 Radar Posts
- 250 EW/HF/Acq Radars (100 active)
- Fire Control Radars
  - 40 Med/Long Range SAM, 10 Active
  - 100 Short Range SAM, 10 Active
  - 160 AAA, 10 Active
- 200 AIs, 40 Active, 10 Types
- 200 Penetrators, 60 Active, 10 Types
- 5 SAM Types
- 5 AAA Types

APPLICATIONS
TEMS

VIRTUAL SIMULATOR TESTING "Laundry List"

- ENVELOPE EXPANSION
- FLIGHT CONTROL FAILURE
- HUMAN FACTOR INTERFACE STUDIES
- EMERGENCY PROCEDURES
- SENSITIVITY ANALYSIS
- MISSION REHEARSAL
- SYSTEM FAMILIARIZATION
- CONTROL SYSTEM FUNCTIONAL TESTING W/ FAILURE STATES
- ANOMALY INVESTIGATION
- EW BLUE/RED OITL
- MANEUVER PRACTICE AND DEFINITION
- AIRCREW & ENGINEER TRAINING
- ACCIDENT INVESTIGATION
- FLIGHT SAFETY EVALUATIONS
- EFFECT OF STORE CARRIAGE
- STORE SEPARATION AND WEAPONS DELIVERY ACCURACY
- CREW RESOURCE TRAINING
- ENGINE TRANSIENTS AND AIRSTARTS
- ANALYSIS AND TRAINING

CAPABILITIES

TEMS

VIRTUAL SIMULATOR ADVANTAGES

- RAPID RECONFIGURATION
- REAL-TIME MODIFICATION OF ANY SIMULATION PARAMETER
- INPUT ACTUAL FLIGHT TEST DATA
- RECORD PILOT INPUTS FOR REPEATABLE MANEUVERING TARGETS
- TAILORABLE VISUAL SCENES 20 - 360 DEGREES
- LINKABLE WITH IFAST OR DIADS FOR HARDWARE-IN-THE-LOOP

CAPABILITIES

IFAST

FACILITY DESCRIPTION

- **AVIONICS HARDWARE-IN-THE-LOOP (HITL) AND SYSTEM INTEGRATION LABS (SILs)**
- **6 SHIELDED SECURE TEST BAYS**
  - FOV of flightline & range
  - Collocation w/CTF's, shared assets
  - Aircraft power, cooling
- **F-16: 1 TEST BAY (7,000 ft2)**
- **F-15: 1 TEST BAY (7,000 ft2)**
- **B-1B: 1.5 TEST BAYS (10,500 ft2)**
  - Offensive and defensive
- **F-22: 2 TEST BAYS (21,000 ft2)**

CAPABILITIES
IFAST

- AIRCRAFT AVIONICS

FIRE CONTROL	RADAR (APG-68/70)
STORES MANAGEMENT	UP-FRONT CONTROLS
HEADS-UP DISPLAY	IDM
MULTIFUNCTION DISPLAY	RADAR WARNING RECEIVER

- AVIONICS LRU COMMUNICATION

F-16 F-15 B-1B F-22 (FALL 96)

- SENSOR SYSTEM INTEGRATION

FCR RWR NVP TGP

- WEAPONS SYSTEM INTEGRATION

AIM-9 AIM-120 AGM-65 HARM SLAM

- NAVIGATION SYSTEM INTEGRATION

INS GPS EGI

- ECM POD CHECKS (ALQ-167 inside, any outside)

HITL APPLICATIONS
IFAST

- SUBSYSTEM OR SUITE SPREAD BENCHES
- PROTOTYPE/PRE-PRODUCTION/ PRODUCTION
- BRASSBOARD/BREADBOARD
- OPERATIONAL SOFTWARE IN TARGET PROCESSOR
- MAY INCLUDE THREAT REPRESENTATIVE HARDWARE / SW / SIGNALS
- DYNAMIC AERO AND SIGNALS ENVIRONMENT
- STORES MAY BE INCLUDED

SIL APPLICATIONS
IFAST

- TESTING WITHIN INTEGRATED AVIONICS "BACKBONE" (F-16, F-15, B-1B, [F-22])
- DEVELOPMENTAL OR TEST PURPOSES
- SOFTWARE AND HARDWARE INTEGRATION
- TESTING HUMAN AND SYSTEMS/ VEHICLE INTERFACES

- MAY INCLUDE OTHER WEAPON SYSTEMS
- USUALLY INCLUDES OTHER ON-BOARD SUB-SYSTEMS (OR HYBRID/EMULATIONS)
- PROTOTYPING TECHNOLOGIES (ADVANCED CONCEPT TECH DEMOS OR OTHER DEMOS WITH REAL HARDWARE)

AFEWES FACILITY

- HARDWARE-IN-THE-LOOP FACILITY
  - EC EFFECTIVENESS
  - OPEN AND CLOSED LOOP
- SAM, AAA, AND AIRBORNE INTERCEPTOR RF THREATS
- INFRARED TEST LABORATORIES
  - SEEKER DEVELOPMENT
  - IRCM DEVELOPMENT
- LOCATED AT AF PLANT 4, FT WORTH TX

CAPABILITIES
BAF

FACILITY DESCRIPTION

- WORLDS LARGEST INSTALLED SYSTEM TEST FACILITY (ISTF) & MEASUREMENT FACILITY (MF)
  - 264ft x 250ft x 70ft (door 200ft x 68ft)
  - PLUS SMALL EMI/EMC TEST ROOM

- LARGE CENTRAL TURNTABLE
  - 80ft DIAMETER, 250,000 lbs CAPACITY
  - +/- 190 DEG ROTATION (0.1-0.6 DG/SEC)
- 2 HOISTS FOR SMALL/MEDIUM AIRCRAFT
  - 80,000 lbs CAPACITY EACH, MAN-RATED

CAPABILITIES
BAF

- AIRCRAFT POWER & UTILITIES
- FREE SPACE RADIO FREQUENCY (0.5-18 GHz)
  - > 100dB ATTENUATION INTRINSICALLY
  - RAM ADDS ADDITIONAL ATTENUATION
  - APPROX 10^6 ft3 QUIET ZONE
- THREAT GENERATION (CEESIM 8000)
  - LAND, SEA, AIRBORNE THREATS
  - 640 SIMULTANEOUS SIGNALS AT DIGITAL LEVEL
  - 100 SIMULTANEOUS SIGNALS GENERATED AT RF
  - TAILORABLE PARAMETERS CORRELATING WITH OAR THREATS

CAPABILITIES
BAF

- FREE SPACE GPS STIMULATORS
  - FULL 24 SATELLITES
  - POSITION ANYWHERE, ANYTIME, ANY VELOCITY
- JAMMER (AN/ULQ-23)
  - 60 FUNCTIONS

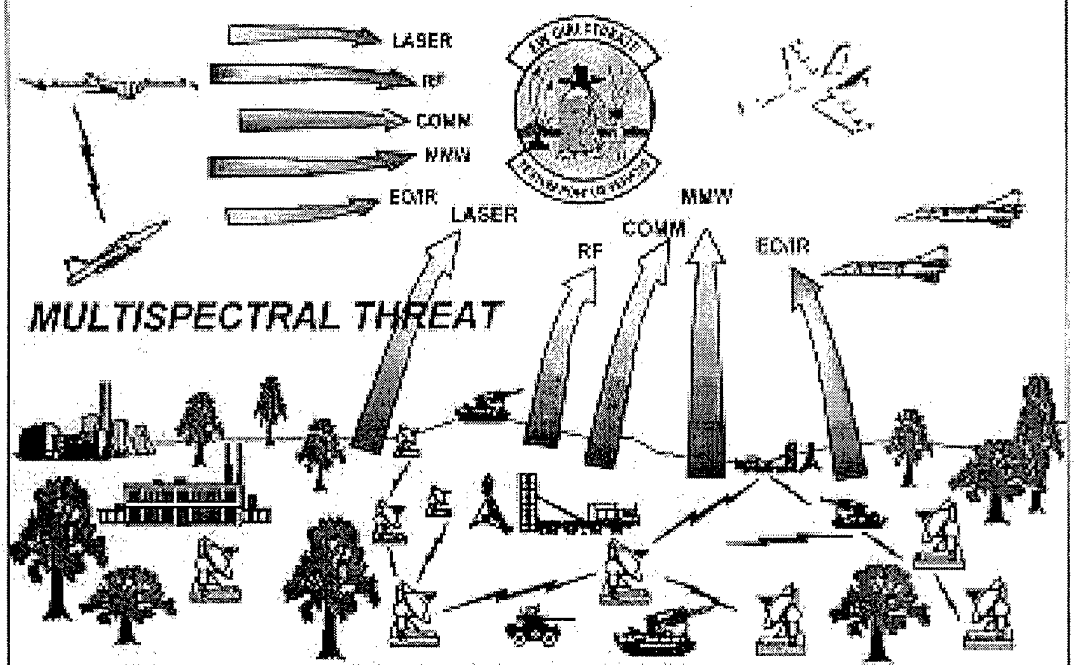
NOISE	DECEPTION
COMB NOISE/DECEPTION	8-11 GHz
VELOCITY GATE STEALER	RANGE GATE STEALER

  - SUPPORT CAPABILITY FOR OTHER JAMMER PODS
- ANTENNA PATTERN MEASUREMENT SYSTEM
- NAV AND AIR DATA COMPUTER DATA STIMULATION

APPLICATIONS
BAF

- ANTENNA PATTERNS
- APERTURE AIRFRAME INTERACTIONS
- MULTI AIRCRAFT INTEROPERABILITY
- AOA ACCURACY
- ECM AND ECCM RESPONSE
- MIN DISCERNIBLE SIGNAL
- THREAT ID
- SYSTEM RESPONSE TIME
- POLARIZATION TESTING
- SECURE EMISSIONS
- UNINTENTIONAL EMISSIONS
- ERP MEASUREMENT
- EMITTER DETECTION, ID AND SYSTEM PERFORMANCE
- TARGET RESOLUTION/ SIGNAL CORRELATION
- MULTI-EMITTER SCENARIO PERFORMANCE
- ANOMALY INVESTIGATION
- EMI/EMC, RF COMPATIBILITY
- SUT CHARACTERIZATION
- RCS/IMAGING
- GPS JAMMING

FUTURE CAPABILITIES



INFORMATION WARFARE

FUTURE ATIC CAPABILITIES

- DIGITAL IADS-REDCAP (DIADS-REDCAP)
  - ON-SITE REDCAP OITL EQUIPMENT
- ELECTRONIC COMBAT INTEGRATED TEST (ECIT) UPGRADES
  - RF CORRELATED EW, CNI, AND RADAR THREAT/TARGETS
  - THREAT/TARGET SIMULATORS TIED TO IFAST
  - MULTISPECTRAL CORRELATED THREATS/TARGETS
  - HIGH FIDELITY IR SCENE (TARGET) GENERATOR
  - LINKAGES TO CO-LOCATED ATIC FACILITIES; BAF, IFAST, TEMS, DIADS
- POD MOUNTED SEEKERS
- AIR WARFARE MISSION SIMULATOR (AWMS)

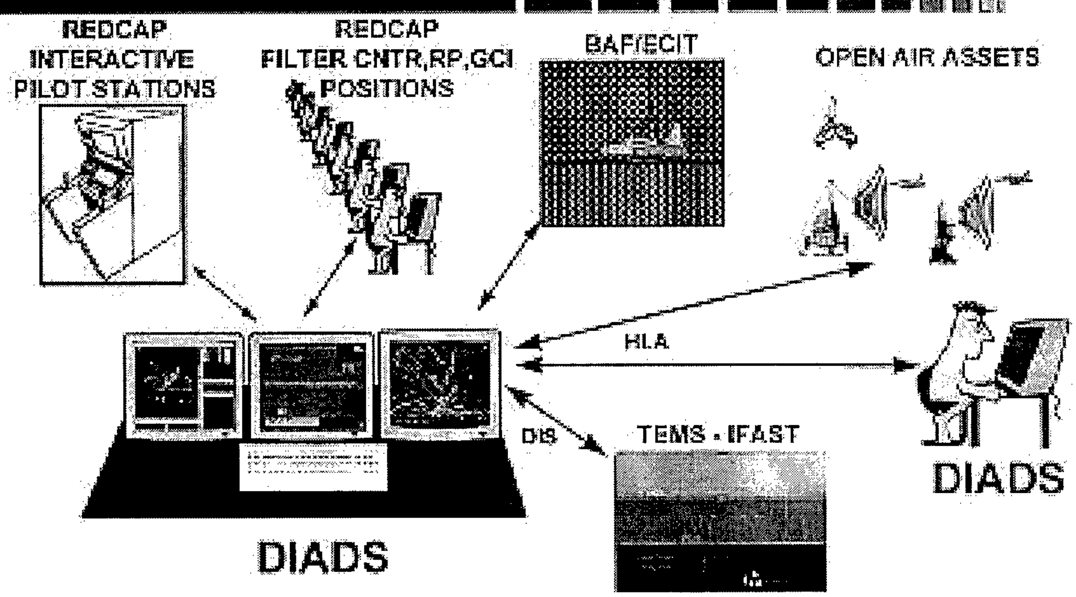
DIADS-REDCAP

REDCAP CAPABILITY LEGACY

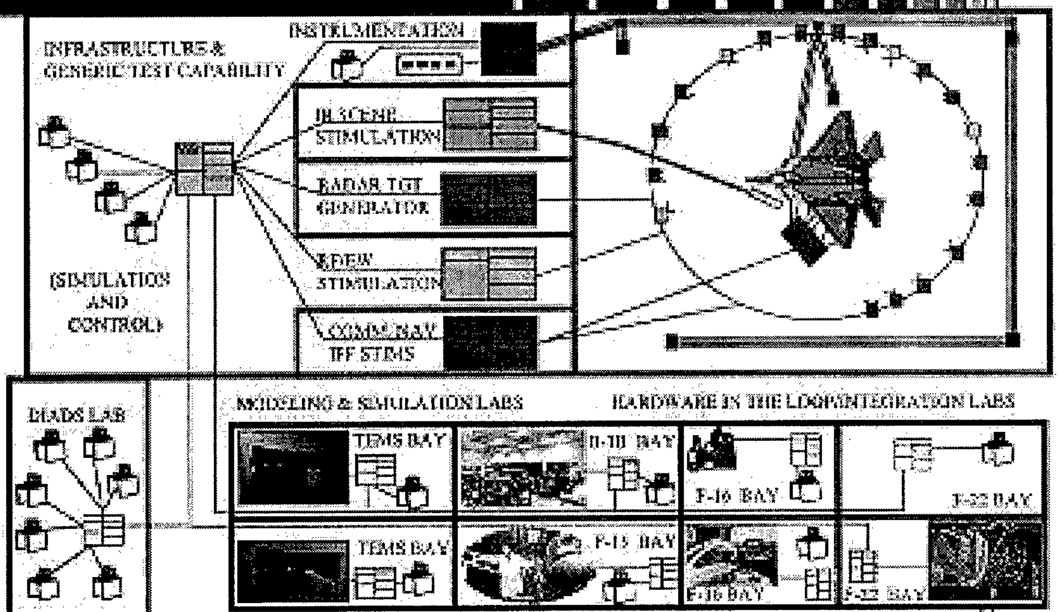
- REDCAP AT BUFFALO NY WAS HITL IADS TESTING CENTER
- BRAC-95 DISESTABLISHED REDCAP
- CAPABILITIES BEING RE-ESTABLISHED AT AFFTC (ATIC) IN FY 99
  - ALL DIGITAL MODEL OF REDCAP (DIADS)
  - MAN-IN-THE-LOOP
  - LINK WITH OPEN AIR RANGE FOR HARDWARE-IN-THE-LOOP

DIADS - REDCAP

Integrated Real Time Operation



ECIT
FUNCTIONAL LAYOUT



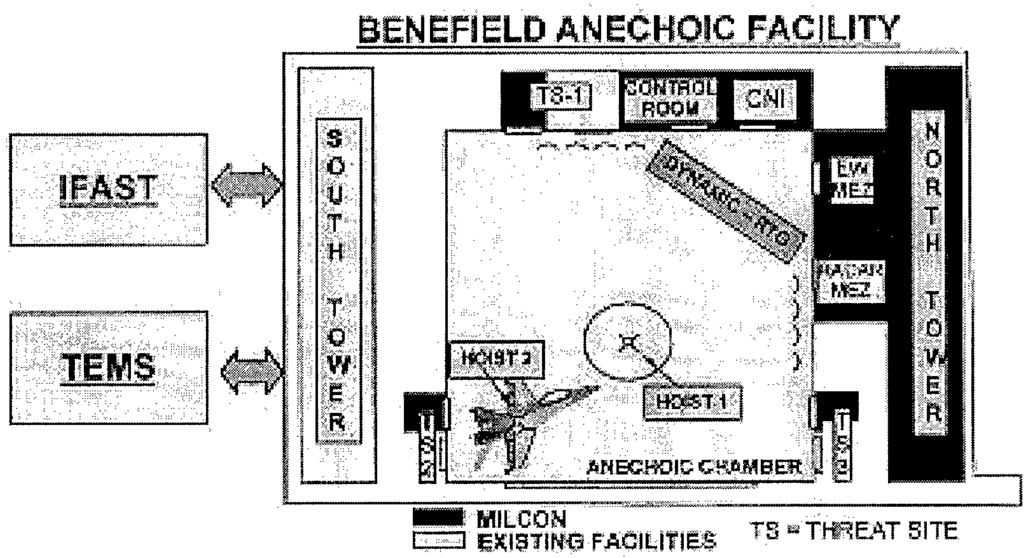
INTEGRATION FACILITY FOR AVIONICS SYSTEMS TEST

CAPABILITIES
ECIT

THREE PHASE APPROACH

- PHASE I: FY99
  - INFRASTRUCTURE & GENERIC TEST CAPABILITY
    - HIGH DENSITY-REALISTIC RF ENVIRONMENT
- PHASE 2: FY00
  - CNI STIMULATION
  - RADAR TARGET GENERATION
  - RF CORRELATED EW, CNI, RADAR THREATS/TARGETS FOR STRESS TESTING
- PHASE 3: FY01
  - EO/IR TARGET GENERATION
  - MULTISPECTRAL CORRELATED THREATS/TARGETS FOR SYSTEM CORRELATION AND DATA FUSION EVALUATION

ECIT
PHYSICAL LAYOUT



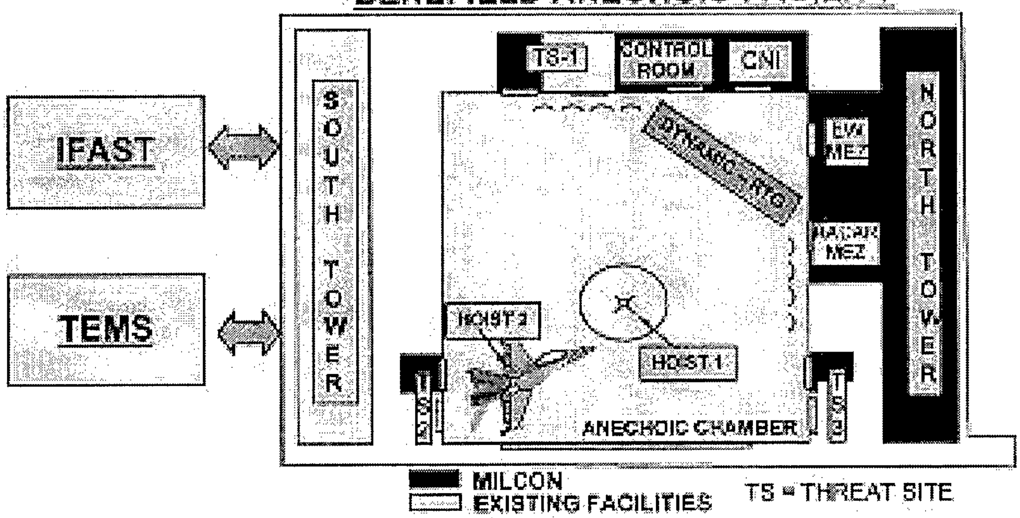
DESIGN CONCEPT

SUMMARY

- Avionics & EW test process are disciplined recursive approach to testing that is "tailored" to your risk management strategy
- Full spectrum of ground facilities available at AFFTC to support risk mitigation
- Ground test facilities complement OAR test capabilities
- Constructive M&S through virtual DIADS and campaign level simulations
- Avionics Integration Labs F-15, F-16, F-22, B-1B
- Large Anechoic Chamber for RF & electromagnetic tests

ECIT
PHYSICAL LAYOUT

BENEFIELD ANECHOIC FACILITY



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- Large Anechoic Chamber for RF & electromagnetic tests

ATIC
POINTS OF CONTACT

- SINGLE-FACE-TO-CUSTOMER: RALPH NELSON OR BOB HANLON
  - *DSN 525-9250/Commercial (805) 275-9250*
- EW: (EW T&E Process) DICK MCQUILLAN
  - *DSN 525-7615/Commercial (805) 275-7615*
- EWW: LT COL RANDY KELLY or RICK STRAMA
  - *DSN 527-5404/Commercial (805) 277-5404*
- EWWA (BAF): PAT DUBRIA
  - *DSN 527-5680/Commercial (805) 277-5680*
- EWWI (IFAST): SHEILA FORRETTE
  - *DSN 527-6589/Commercial (805) 277-6589*
- EWWS (TEMS&DIADS/REDCAP): JOE PIOTROWSKI
  - *DSN 527-7676/Commercial (805) 277-7676*
- OL-AB (AFEWES): LT COL JAIME SILVA
  - *DSN 838-5856/Commercial (817) 763-4856*

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